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FRIDAY, AUGUST 27, 1897.

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AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

A CHAPTER IN THE HISTORY OF MATHEMATICS.*

On the 10th of March, 1897, a hundred years after its original presentation, the Royal Academy of Sciences and Letters of

* Address by the Vice-President before Section A, Mathematics and Astronomy.

Denmark published a French translation of a memoir by Caspar Wessel, entitled *Om Direktionens analytiske Betegning, et Forsøg, anvendt fornemmelig til plane og sphæriske Polygoners Oplosning*, or an Essay on the Analytic Representation of Direction, with Applications in Particular to the Determination of Plane and Spherical Polygons.

This paper, which deals with the geometric representation of imaginary quantities; which was read and printed several years before the famous essay of Argand and contains fully as exact a treatment of the subject, lay buried for nearly a century until attention was again drawn to it in 1895 by a thesis of S. D. Christensen upon the development of mathematics in Denmark and Norway in the eighteenth century.

Inasmuch as this memoir of Wessel's is still comparatively unknown, I have thought that it would not be uninteresting at this time to present a sketch of the development of the geometric treatment of the imaginary, particularly in the latter part of the eighteenth century and the first part of the nineteenth.

We find the square root of a negative quantity appearing for the first time in the *Stereometria* of Heron of Alexandria, 100 B. C. After having given a correct formula for the determination of the volume of a frustum of a pyramid with square base and applied it successfully to the case where the side of

the lower base is 10, of the upper 2, and the edge 9, the author endeavors to solve the problem when the side of the lower base is 28, of the upper 4, and the edge 15. Instead of the square root of 81-144 required by the formula, he takes the square root of 144-81 and calls it equal to 8 less $\frac{1}{16}$, i. e., he replaces $\sqrt{-1}$ by 1, and fails to observe that the problem as stated is impossible. Whether this mistake was due to Heron or to the ignorance of some copyist cannot be determined.

In the solution of the problem to find a right angled triangle whose perimeter is 12 and area 7, Diophantus, in his *Arithmetica*, 300 A. D., reaches the equation $336x^2 + 24 = 172x$ and says that the equation cannot be solved unless the square of the half coefficient of x diminished by the product of 24 and the coefficient of x^2 is a square. No notice is taken of the fact that the value of x in this equation actually involves the square root of a negative quantity.

Bhaskara, born 1114 A. D., in his chapter *Vija Ganita*, was able to go a step further. He gave the rule :

The square of a positive number as also of a negative number is positive and the square root of a positive number is twofold, positive and negative. There is no square root of a negative number, for this is not a square.

The first mathematician who had the courage actually to use the square root of a negative number in computation was Cardano. At an earlier period he had declared such a quantity to be wholly impossible, but in the *Ars Magna*, 1545, he discusses the problem of dividing 10 into two parts whose product shall be 40 and obtains the values $5 + \sqrt{-15}$, $5 - \sqrt{-15}$. These he verifies by multiplication. Such quantities he calls sophistic, since it is not permissible to operate with them as with pure negative numbers or others, nor to assign them a meaning.

Bombelli, in his *Algebra*, 1572, gives a

number of rules for the use of such quantities as $a+b\sqrt{-1}$, but makes no endeavor to explain their character.

Girard knew that every equation has as many roots as its degree indicates and consequently recognized the existence of imaginary roots. In his *Invention nouvelle en l'algèbre*, 1629, while discussing the roots of the equation $x^4 - 4x + 3 = 0$ he asks what purpose is subserved by such roots as $-1 + \sqrt{-2}$ and $-1 - \sqrt{-2}$ and says that they show the generality of the law of formation of the coefficients and are useful of themselves.

Descartes, in his *Geometria*, 1637, gives us no new ideas upon the subject, but is the first to apply the terms real and imaginary by way of contrast to the roots of an equation.

Wallis, in his *Treatise of Algebra*, 1685, leads the van in his endeavor to give a geometric interpretation to the square root of a negative number. In chapter LXVI we read :

These *Imaginary Quantities* (as they are commonly called) arising from the *Supposed Root* of a Negative Square (when they happen,) are reputed to imply that the Case proposed is Impossible.

And so indeed it is, as to the first and strict notion of what is proposed. For it is not possible that any Number (Negative or Affirmative) Multiplied into itself can produce (for instance) -4. Since that Like Signs (whether + or -) will produce +; and therefore not -4.

But it is also Impossible that any Quantity (though not a Supposed Square) can be *Negative*. Since that it is not possible that any *Magnitude* can be *Less than Nothing* or any *Number Fewer than None*.

Yet it is not that Supposition of Negative Quantities, either Unuseful or Absurd; when rightly understood. And though, as to the bare Algebraick Notation, it import a Quantity less than nothing. Yet, when it comes to a Physical Application, it denotes as Real a Quantity as if the Sign were +; but to be interpreted in a contrary sense.

He illustrates this by distances measured forward and backward upon a straight line in the usual way, and continues :

Now what is admitted in Lines must, on the same Reason, be allowed in Plains also.

Having thus justified the existence of negative planes, he goes on :

But now (supposing this Negative Plain, —1600 Perches, to be in the form of a Square;) must not this Supposed Square be supposed to have a Side? And if so, what shall this Side be?

We cannot say it is 40, nor that it is -40^{**}

But thus rather that it is $\sqrt{-1600}$, or $** 10\sqrt{-16}$, or $20\sqrt{-4}$, or $40\sqrt{-1}$.

Where $\sqrt{}$ implies a Mean Proportional between a Positive and a Negative Quantity. For like as \sqrt{bc} signifies a Mean Proportional between $+b$ and $+c$; or between $-b$ and $-c$; $**$ So doth $\sqrt{-bc}$ signify a Mean Proportional between $+b$ and $-c$, or between $-b$ and $+c$.

In chapter LXVII Wallis gives a geometric exemplification of a mean proportional, interpreting \sqrt{bc} as a sine in a circle whose diameter $= b+c$, and $\sqrt{-bc}$ as a tangent in a circle whose diameter $= -b+c$. He then finds the base of a triangle when the two sides and the angle opposite, and hence the altitude, are given. Assuming $AP=20$, $PB=15$, and the altitude $PC=12$, by the use of the triangle BCP , right-angled at C , he obtains two values for the base AB . Then taking $AP=20$, $PB=12$, and the altitude $PC=15$, he finds imaginary values for the base.

These he interprets by saying :

This Impossibility in *Algebra* argues an Impossibility of the case proposed in Geometry; and that the Point B cannot be had, (as supposed,) in the Line AC , however produced (forward or backward,) from A .

Yet there are Two Points designed (out of that Line, but) in the same Plain; to either of which, if we draw the Lines AB , BP , we have a Triangle; whose Sides, AP , PB , are such as were required: And the Angle PAC , and Altitude PC , (above AC , though not above AB), such as was proposed:

In this case he takes the triangle BCP to be right angled at B . Further :

And (in the Figure,) though not the Two Lines themselves, AB , AB , (as in the First case, where they lay in the Line AC ;) yet the Ground-Lines on which they stand, $A\beta$, $A\beta$, are equal to the Double of AC : That is, if to either of those AB , we join $B\alpha$, equal to the other of them, and with the same Declivity; $AC\alpha$

(the distance of $A\alpha$) will be a Straight Line equal to the double of AC ; as is $AC\alpha$ in the First case.

The greatest difference is this; that in the first Case, the Points B , B , lying in the Line AC , the Lines AB , AB , are the same with their Ground-Lines, but not so in this last case where B , B are so raised above $\beta\beta$ (the respective Points in their Ground-Lines, over which they stand), as to make the case feasible; (that is, so much as is the versed sine of CB to the Diameter PC .) But in both $AC\alpha$ (the Ground-Line of $AB\alpha$) is equal to the Double of AC .

So that, whereas in case of Negative Roots, we are to say, The Point B cannot be found, so as is supposed in AC Forward, but Backward from A it may in the same Line: We must here say, in case of a Negative Square, the Point B cannot be found so as was supposed, in the Line AC ; but Above that Line it may in the same Plain. This I have the more largely insisted upon, because the Notion (I think) is new; and this, the plainest Declaration that at present I can think of, to explicate what we commonly call the *Imaginary Roots* of Quadratic Equations. For such are these.

From these extracts it is evident that Wallis possessed, at least in germ, some elements of the modern methods of addition and subtraction of directed lines.

For the next hundred years no advance of importance was made. Euler, for example, makes large use of the imaginary, but in his *Algebra*, 1770, he observes :

All such expressions as $\sqrt{-1}$, $\sqrt{-2}$, etc., are consequently impossible or imaginary numbers, since they represent roots of negative quantities; and of such numbers we may truly assert that they are neither nothing, nor greater than nothing, nor less than nothing, which necessarily constitutes them imaginary or impossible.

On the 10th of March, 1797, a surveyor named Wessel presented to the Royal Academy of Sciences and Letters of Denmark a memoir 'On the Analytic Representation of Direction,' which was printed in 1798 and appeared in Vol. V, of the Memoirs of the Academy in 1799.

Caspar Wessel was born June 8, 1745, at Jonsrud, in Norway, where his father was a pastor. Though one of thirteen children, he had a good education, for in 1757 he entered the high school at Christiania and

in 1763 went to Copenhagen to pursue further studies. In 1764 he was engaged by the Academy of Sciences as an assistant in the triangulation and preparation of a map of Denmark. Till 1805 he remained in the continuous employ of the Academy as surveyor. Wessel was highly esteemed by his contemporaries, and for some special work done after leaving the service of the Academy he received the Academy's silver medal and a full set of its memoirs. In 1819, when many of its maps were declared out of date, the trigonometric determinations of Wessel were made a special exception. In 1778 he passed an examination in Roman law. In 1815 he was made a Knight of the Danebrog. He died in 1818.

While Wessel was always well spoken of as a surveyor, he was never mentioned as a mathematician. Still the fact that his paper was the first to be accepted by the Academy from one not a member argues in his favor. This acceptance was due to Tetens, Councillor of State, to whom the MS. had been shown and whose assistance in improving it was acknowledged. In the History of the Academy of Sciences of Denmark published in 1843 Professor Jürgensen classes Wessel with others in the statement, "The treatises of the other mathematicians are monographs of no considerable scientific value," or "They are too special to be discussed more at length."

In the introduction to his memoir Wessel says:

The present essay has for its object to determine how to express segments of straight lines when we wish by means of a unique equation between a single unknown segment and other given segments to find an expression representing at once the length and direction of the unknown segment.

To be able to answer this question I shall employ two considerations which seem to me evident. In the first place, the variation of direction which may be produced by algebraic operations ought also to be represented by their symbols. In the second place we submit direction to algebra only by making its variation depend upon algebraic operations. Now

according to the ordinary conception we can transform it by these operations only into the opposite direction, that is, from positive into negative and reciprocally. It follows that these two directions only would be susceptible of an analytic representation adapted to the usual conception and that the solution of the problem would be impossible for other directions. It is probably for this reason that nobody has given attention to this subject. Doubtless nobody has felt at liberty to change the definition of these operations once adopted. To this there is no objection so long as the definition is applied to ordinary quantities; but there are special cases where the peculiar nature of the quantities seems to invite us to give particular definitions to the operations. Then if we find these definitions advantageous it seems to me that we ought not to reject them. For in passing from arithmetic to geometric analysis, that is to say, from operations relative to abstract numbers to operations upon segments of a straight line, we shall have to consider quantities which may have to one another not only the same relations as abstract numbers, but also a great number of new relations. Let us try them to generalize the signification of our operations; let us not restrict ourselves, as has been done hitherto, to the employment of segments of a straight line in the same or opposite sense, but extend a little the notion of the way in which they are applied not only to the same cases as heretofore, but to an infinite number of other cases. If at the same time that we take this liberty we have respect to the ordinary rules of operations we in no way contravene the ordinary theory of numbers, but we merely develop it, we accommodate ourselves to the nature of the quantities and observe the general rule which requires us to render a difficult theory little by little more easy to comprehend. It is not then absurd to demand that in geometry operations be taken in a broader sense than in arithmetic. We shall admit without difficulty that it will be possible to vary the direction of segments in an infinite number of ways. Precisely by this means (as we shall show later) we succeed not only in avoiding all impossible operations and in explaining the paradox that it is necessary sometimes to resort to the impossible to obtain the possible, but we also succeed in expressing the direction of line-segments situated in the same plane quite as analytically as their length, without the memoir being embarrassed by new symbols or new rules. Now it must be agreed that the general demonstration of geometric theorems often becomes easier when we express direction in an analytic manner and submit it to the rules of algebraic operations than when we are compelled to represent it by figures which are applicable only to particular cases.

For these reasons I have proposed to myself :
 1° to give the rules of operations of this nature ;
 2° to show by examples the application to cases where the segments are found in the same plane ;
 3° to determine by a new method not algebraic the direction of segments situated in different planes ;
 4° to deduce the general solution of plane and spherical polygons ;
 5° to deduce in the same way the known formulæ of spherical trigonometry.

This, in brief, is an outline of the present memoir. I was led to write it by my desire to find a method which would enable me to avoid impossible operations; having discovered it I have made use of it to convince myself of the generality of certain known formulæ.

How well the author succeeds in carrying out his plan is shown by the memoir itself. Wessel says :

The addition of two segments is effected in the following manner : we combine them by drawing the one from the point where the other terminates ; then we join by a new segment the two ends of the broken line thus determined.

He extends the definition to more than two segments and affirms :

In the addition of segments, the order of terms is arbitrary and the sum always remains the same.

His definition of the product of two segments is especially noteworthy :

The product of the two line-segments ought in every respect to be formed with one of the factors in the same way as the other factor is formed, with the positive or absolute segment taken equal to unity ; that is to say :

1° The factors ought to have such a direction that they can be placed in the same plane as the positive unit ;

2° As to length the product should be to one of the factors as the other is to the unit ;

3° As to the direction of the product, if we draw from the same origin the positive unit, the factors and the product, the latter ought to be in the plane of the unit and the factors, and ought to deviate from one of the factors by as many degrees and in the same sense as the other deviates from the unit so that the angle of direction of the product or its deviation with respect to the positive unit is equal to the sum of the angles of direction of the factors.

Let us designate by $+1$ the positive rectilinear unit, by $+\varepsilon$ another unit perpendicular to the first and having the same origin ; then the angle of direc-

tion of $+1$ will be equal to 0° , that of -1 to 180° , that of $+\varepsilon$ to 90° and that of $-\varepsilon$ to -90° or to 270° ; and according to the rule that the angle of direction of the product is equal to the sum of the angles of the factors, we shall have : $(+1) \cdot (+1) = +1$, $(+1) \cdot (-1) = -1$, $(-1) \cdot (-1) = +1$, $(+1) \cdot (-\varepsilon) = -\varepsilon$, $(-1) \cdot (+\varepsilon) = -\varepsilon$, $(-1) \cdot (-\varepsilon) = +\varepsilon$, $(+\varepsilon) \cdot (+\varepsilon) = -1$, $(+\varepsilon) \cdot (-\varepsilon) = +1$, $(-\varepsilon) \cdot (-\varepsilon) = -1$. Hence it follows that ε is equal to $\sqrt{-1}$ and that the deviation of the product is determined so that we violate none of the ordinary rules of operation.

It is interesting to note that while Wessel makes the addition and multiplication of directed lines a matter of definition, Argand, in his famous memoir of 1806, *Essai sur une manière de représenter les quantités imaginaires dans les constructions géométriques*, says: "Inasmuch as these principles depend upon inductions which are not securely established, they cannot as yet be considered as other than hypotheses whose acceptance or rejection should depend upon either the consequences which they entail or a more rigorous logic," although in his last contribution to the *Annales de Gergonne* he grants that this difficulty will vanish if with M. Français we define what is meant by a ratio of magnitude and position between two lines.

After explaining that if v represents any angle, and $\sin v$ a segment equal in length to the sine, positive when the measuring arc terminates in the first semicircumference and negative when it terminates in the second, $\sin v$ will express the sine of the angle v in direction and magnitude, Wessel shows that any radius making the angle v with the positive unit will equal $\cos v + \varepsilon \sin v$. In the multiplication of two radii $\cos v + \varepsilon \sin v$, $\cos u + \varepsilon \sin u$, he establishes the distributive law by reference to the formulæ,

$$\sin(v+u) = \sin v \cos u + \cos v \sin u,$$

$$\cos(v+u) = \cos v \cos u - \sin v \sin u,$$

in contrast to Argand, who assumes the distributive law and then derives the trigonometric formulæ.

A statement in this connection is noteworthy:

But if we have to multiply line segments which are not both in the plane passing through the absolute unit we cannot apply the preceding rule. For this reason I do not consider the multiplication of such segments.

The treatment of division follows in a natural manner, and it is proved that indirect quantities share with direct quantities the property that if the dividend is a sum we obtain by dividing each term of the sum by the divisor several quotients whose sum is the quotient sought.

Then comes a discussion of powers and roots establishing the fact that $(\cos v + \varepsilon \sin v)^m$ has m different values and only m . In the next paragraph Wessel shows that the m^{α} power of a line-segment may be put in the form $e^{ma+mb^{\gamma-1}}$, where e^m represents the length and mb the angle of direction, and that thus we have a new method of representing the direction of line-segments in the same plane by the aid of natural logarithms. This last is not again referred to, but it is readily seen that Wessel was in possession of all three of the present methods of representing the complex number,

$$a+b\sqrt{-1}, r(\cos \varphi + \sqrt{-1} \sin \varphi) \text{ and } re^{b^{\gamma-1}}.$$

At the close of this section the author remarks:

At another time, with the permission of the Academy, I will present the complete proofs of these theorems. Having given an account of the way in which we must, in my judgment, understand the sum, the product, the quotient and power of line segments, I shall restrict myself to a few applications of the method.

The first application is to a demonstration of Cotes's theorem in which the fundamental theorem of algebraic equations is assumed as previously established. The second is to the resolution of plane polygons. In this certain characteristic notations occur. The first side of the quadrilateral considered is taken equal to the

absolute unit; the sides in order beginning with the first are designated by the even numbers II, IV, VI, VIII, while I, III, V, VII, represent their deviations (in degrees) each with respect to the preceding side prolonged, regarding these deviations as positive or negative according as they have the same sense as the diurnal motion of the sun or the opposite; I', III', V', VII' denote the expressions $\cos I + \varepsilon \sin I$, etc., while I'', III'', V'', VII'' denote the expressions $\cos (-I) + \varepsilon \sin (-I)$ or $\cos I - \varepsilon \sin I$, etc.

The author then deduces the two formulæ,

$$\text{II} + \text{IV} \cdot \text{III}' + \text{VI} \cdot \text{III}' \cdot \text{V}' + \text{VIII} \cdot \text{III}' \cdot$$

$$\text{V}' \cdot \text{VII}' = 0,$$

$$\text{II} \cdot \text{III}' \cdot \text{V}' \cdot \text{VII}' + \text{IV} \cdot \text{V}' \cdot \text{VII}' + \text{VI} \cdot$$

$$\text{VII}' + \text{VIII} = 0,$$

and proves that two equations of this form will suffice for the solution of any polygon in which the only unknown parts are three angles, or two angles and a side, or an angle and two sides.

Wessel next attacks the problem of representing the direction of any line segment in space by taking it as the radius, r , of a sphere. Assuming three perpendicular radii as axes and denoting positive unit lengths upon these, to the left by 1, forward by ε and upward by γ respectively, where $\varepsilon^2 = -1$, and $\gamma^2 = -1$, he concludes that a radius whose extremity has for coordinates $x, \gamma y, \varepsilon z$ will be properly designated by $x + \gamma y + \varepsilon z$. Defining the plane of r and εr as the horizontal plane and that of r and γr as the vertical plane, he examines the effect of moving the extremity through an arc of I degrees parallel to the horizontal plane and obtains for $x + \gamma y + \varepsilon z$ the new value,

$$\gamma y + (x + \varepsilon z) (\cos I + \varepsilon \sin I) = \gamma y + x \cos I - z \sin I + \varepsilon x \sin I + \varepsilon z \cos I,$$

in which the term γy remains unchanged. This operation he indicates by the use of

the sign „, as $(x + \eta y + \varepsilon z)$ „, $(\cos I + \varepsilon \sin I)$ and says that it has only imperfectly the signification of a sign of multiplication, for the operation leaves unchanged that one of the segments occurring in the multiplicand which is outside of the plane corresponding to the rotation indicated by the multiplier. He calls attention to the fact that the factors must be used in order from left to right. Similarly when the extremity of the radius moves through an arc of II degrees parallel to the vertical plane we have

$$(x + \eta y + \varepsilon z) „, (\cos II + \eta \sin II) = \\ \varepsilon z + x \cos II - y \sin II + \eta x \sin II + \\ \eta y \cos II.$$

It follows at once that

$$(x + \eta y + \varepsilon z) „, (\cos I + \varepsilon \sin I) „, \\ (\cos III + \varepsilon \sin III) = (x + \eta y + \varepsilon z) „, \\ (\cos (I + III) + \varepsilon \sin (I + III))$$

and

$$(x + \eta y + \varepsilon z) „, (\cos II + \eta \sin II) „, \\ (\cos IV + \varepsilon \sin IV) = (x + \eta y + \varepsilon z) „, \\ (\cos (II + IV) + \varepsilon \sin (II + IV))$$

also that

$$x + \eta y + \varepsilon z = (x + \eta y + \varepsilon z) „, (\cos I + \varepsilon \sin I) „, (\cos I - \varepsilon \sin I) = (x + \eta y + \varepsilon z) „, \\ (\cos II + \eta \sin II) „, (\cos II - \eta \sin II).$$

Wessel then studies the effect of alternate horizontal and vertical rotations. Representing the radius in its first position by s and in its final position by S , and denoting the arcs in order by I, II, III, * * * VI, he obtains the formula

$$S = s, I' „, II' „, III' „, IV' „, V' „, VI'.$$

In this connection he observes that such factors as V' „, VI' can be transferred to the first member by using their reciprocals in inverse order, as

$$S, VI'^{-} „, V'^{-} „, IV'^{-} = s, I' „, II' „, III' „.$$

These results are applied to the solution of spherical polygons and the determination of the properties of spherical triangles. As in the case of plane polygons, I, II, III, etc.,

represent the exterior angles and sides in order, the odd numbers the angles, and the even numbers the sides. Supposing the angles and the sides of a polygon known except one angle and two sides, or two angles and a side, or three angles, or three sides, the unknown parts can be determined by the equation

$$s „, I' „, II' „, III' „, IV' „, V' „, \\ VI' „, \dots, N' = s,$$

where s is indeterminate, and may be supposed equal to r , εr , or ηr . The effect of the rotations indicated by this equation is to submit the sphere alternately to rotations about the axis of the horizon and the axis of the vertical circle so that each point of the sphere describes first a horizontal arc which measures the first exterior angle of the polygon, then a vertical arc containing as many degrees as the first side of the polygon, then a new horizontal arc which measures the second angle, etc. The sphere finally returns to its original position, while each of its points has described as many horizontal arcs as the polygon has angles and as many vertical arcs as it has sides.

While Wessel's results, as obtained by these alternate rotations, are correct so far as they go, he fails to observe that a general rotation must be compounded of three rotations about the axes ε , η , ε or η , ε , η . Stranger still he makes no study of rotations about the real axis. Thiele, in his introduction to Wessel's memoir, shows how easy it would have been to go a few steps further and arrive at the notion of quaternions. But be that as it may, Wessel deserves great credit for having devised the only successful method of dealing with line-segments in space previous to the work of Hamilton beginning in 1843.

Unmindful of Euler's demonstration of the real value of $(\sqrt{-1})^{r-1}$ Argand endeavors to show that such an expression may be used to represent a directed line in

space. Français tries to solve the problem by the use of imaginary angles, but frankly acknowledges his failure. Servois sees with remarkable clearness what is needed, but is unable to reach it. He says :

The table of double argument which you (Geronne) propose, as applied to a plane supposed to be so divided into points or *infinitesimal* squares that each square corresponds to a number which would be its *index*, would very properly indicate the length and position of the radii vectores which revolve about the point or central square corresponding to ± 0 ; and it is quite remarkable that if we designated the length of a radius vector by a , and the angle it makes with the real line....., -1 , ± 0 , $+1$ by a , the rectangular coordinates of its *extremity remote from the origin* by x, y , the real line being the axis of x , the point would be determined by $x+y\sqrt{-1}$ It is clear that your ingenious tabular arrangement of numerical magnitudes may be regarded as a central slice (*tranche centrale*) of a table of triple argument representing points and lines in tri-dimensional space. You will doubtless give to each term a trinomial form; but what would be the coefficient of the third term? For my part I cannot tell. Analogy would seem to indicate that the trinomial should be of the form $p \cos a + q \cos \beta + r \cos \gamma$, a, β , and γ being the angles made by a right line with three rectangular axes and that we should have

$$(p \cos a + q \cos \beta + r \cos \gamma) (p' \cos a + q' \cos \beta + r' \cos \gamma) \\ = \cos^2 a + \cos^2 \beta + \cos^2 \gamma = 1.$$

The values of p, q, r, p', q', r' satisfying this condition would be *absurd*, but would they be *imaginaries*, reducible to the general form $A + B\sqrt{-1}$?

As we all know now, these non-reals which Servois could not determine may be identified with the $+i, +j, +k, -i, -j, -k$, of Hamilton's Quaternions.

In 1799, in his first published paper, *Demonstratio nova theorematis omnem functionem algebraicam rationalem integrum unius variabilis in factores reales primi vel secundi gradus resolvi posse*, the celebrated Gauss, then only twenty-two years of age, says :

By an imaginary quantity I always understand here a quantity contained in the form $a+b\sqrt{-1}$, so long as b is not zero. * * * If imaginary quantities are to be retained in analysis (which for many reasons seems better than to abolish them, provided they are

established on a sufficiently solid foundation) it is necessary that they be considered as equally possible with real quantities, on which account I should prefer to include both real and imaginary quantities under the common designation *possible quantities*. * * * A vindication of these (*i. e.*, imaginary quantities), as well as a more fruitful exposition of the whole matter, I reserve for another occasion.

This occasion, however, does not seem to have come till more than thirty years later. In the *Göttingische gelehrte Anzeigen* of April 23, 1831, in an account by Gauss of his own paper *Theoria residuorum biquadraticorum, Commentatio secunda*, we read :

Our general arithmetic, so far surpassing in extent the geometry of the ancients, is entirely the creation of modern times. Starting originally from the notion of absolute integers, it has gradually enlarged its domain. To integers have been added fractions, to rational quantities the irrational, to positive the negative and to the real the imaginary. This advance, however, has always been made at first with timorous and hesitating step. The early algebraists called the negative roots of equations false roots, and these are indeed so when the problem to which they relate has been stated in such a form that the character of the quantity sought allows of no opposite. But just as in general arithmetic no one would hesitate to admit fractions, although there are so many countable things where a fraction has no meaning, so we ought not to deny to negative numbers the rights accorded to positive simply because innumerable things allow no opposite. The reality of negative numbers is sufficiently justified since in innumerable other cases they find an adequate substratum. This has long been admitted, but the imaginary quantities—formerly and occasionally now, though improperly, called impossible—as opposed to real quantities are still rather tolerated than fully naturalized, and appear more like an empty play upon symbols to which a thinkable substratum is denied unhesitatingly by those who would not deprecate the rich contribution which this play upon symbols has made to the treasure of the relations of real quantities.

The author has for many years considered this highly important part of mathematics from a different point of view, where just as objective an existence may be assigned to imaginary as to negative quantities, but hitherto he has lacked opportunity to publish these views, though careful readers may find traces of them in the memoir upon equations which appeared in 1799 and again in the prize memoir upon the transformation of surfaces. In the present paper

the outlines are given briefly; they consist of the following:

Positive and negative numbers can only find an application when the thing counted has an opposite which when conceived of as united with it has the effect of destroying it. Accurately speaking, this supposition can only be made where the things enumerated are not substances (objects thinkable in themselves), but relations between any two objects. It is postulated that these objects are arranged after a definite fashion in a series, *e. g.*, *A, B, C, D, * * ** and that the relation of *A* to *B* can be regarded as equal to that of *B* to *C*, etc. The notion of opposition involves nothing further than the interchange of the terms of the relation so that if the relation of (or transition from) *A* to *B* is considered as $+1$ the relation of *B* to *A* must be represented by -1 . So far then as such a series is unlimited on both sides, every real integer represents the relation of a term arbitrarily taken as origin to a definite term of the series.

If, however, the objects are of such a kind that they cannot be arranged in one series, even though unlimited, but only in series of series, or, what amounts to the same thing, they form a manifoldness of two dimensions; if there is the same connection between the relations of one series to another, or the transitions from one to another, as in the case of the transition from one term of a series to another term of the same series, we shall evidently need for the measurement of the transition from one term of the system to another, besides the previous units $+1$ and -1 , two others opposite in character $+i$ and $-i$. Obviously we must also postulate that the unit i shall always mark the transition from a given term of the one series to a definite term of the immediately adjacent series. In this way the system can be arranged in a two-fold manner in series of series.

The mathematician leaves entirely out of consideration the nature of the objects and the content of their relations. He has simply to do with the enumeration and comparison of the relations. So far as he has assigned sameness of nature to the relations designated by $+1$ and -1 , considered in themselves, he is warranted in extending such sameness to all four elements $+1, -1, +i, -i$.

These relations can be made intuitive only by a representation in space and the simplest case, where there is no reason for arranging the objects in any other than quadratic fashion, is that in which an unlimited plane is divided into squares by two systems of parallel lines intersecting at right angles, and the points of intersection are selected as the symbols. Every such point has four adjacent points, and if we designate the relation *A* to a neighboring point by $+1$, the relation to be denoted by -1 is determined of itself, while we

can select which of the two others we please for $+i$, or can take the point to be denoted by $+i$ at pleasure on the *right* or *left*. This distinction between right or left so soon as we have fixed (at pleasure) upon forwards and backwards in the plane, and above and below with respect to the two sides of the plane is completely determined in *itself*, although we can convey our own intuition of this difference to others *only* by reference to actually existent material things. But when we have decided upon the latter we see that it is still a matter of choice as to which of the two series intersecting at one point we shall regard as the principal series and which direction in it shall be considered as having to do with positive numbers. We see further that if we wish to take $+1$ for the relation previously expressed by $+i$, we must necessarily take $+i$ for the relation previously expressed by -1 . In the language of mathematicians this means that $+i$ is a mean proportional between $+1$ and -1 , or corresponds to the symbol $\sqrt{-1}$. We say purposely not *the* mean proportional because $-i$ has just as good a right to that designation. Here then the demonstrability of an intuitive signification of $\sqrt{-1}$ has been fully justified and nothing more is necessary to bring this quantity into the domain of objects of arithmetic.

We have thought to render the friends of mathematics a service by this brief exposition of the principal elements of a new theory of the so-called imaginary quantities. If people have considered this subject from a false point of view and thereby found a mysterious obscurity, this is largely due to an unsuitable nomenclature. If $+1, -1, \sqrt{-1}$ had not been called positive, negative, imaginary (or impossible) unity, but perhaps direct, inverse, lateral unity, such obscurity could hardly have been suggested. The subject which, properly enough, in the present treatise has been touched upon only incidentally the author has reserved for a more elaborate treatment in the future where also the question will be answered as to why the relations between things which present a manifoldness of more than two dimensions cannot furnish still other classes of magnitudes admissible in general arithmetic.

Such was Gauss's masterly presentation of the underlying principles of the treatment of the imaginary. In Germany the impulse given by his commanding influence is felt even to the present day.

Buée's memoir *Sur les Quantités Imaginaires*, read before the Royal Society of London in 1805 and covering 65 pages of the Philosophical Transactions of 1806, is somewhat

vague and disappointing. He describes $\sqrt{-1}$ as follows :

$\sqrt{-1}$ is the sign of perpendicularity. $\sqrt{-1}$ is not the sign of an arithmetical operation, nor of an arithmetico-geometric operation, but of an operation purely geometric. It is a purely descriptive sign which indicates the direction of a line without regard to its length.

Near the close of his paper he investigates what becomes of the conic sections when their coordinates become imaginary and decides that the circle passes into an equilateral hyperbola in the plane perpendicular to the plane of the circle and similarly for the other conics.

A further discussion of the justly celebrated epoch-making memoir of Argand and the contributions of himself, Français-Gergonne and Servois to the *Annales de Gergonne* from 1813 to 1815 is rendered the less necessary by reason of Houel's republication of all these papers in 1874 and their translation into English by Hardy in 1881.

It is interesting to note the early view of imaginaries entertained by so distinguished a mathematician as Cauchy. In his *Cours d' Analyse*, 1821, we read :

In analysis we apply the term symbolic expression or symbol to every combination of algebraic signs which signifies nothing by itself or to which we attribute a value different from that which it naturally ought to have. * * * * Among the symbolic expressions whose consideration is of importance in analysis we ought especially to distinguish those which are called imaginary. * * * * We write the formula

$$\frac{\cos(a+b) + \sqrt{-1} \sin(a+b)}{(\cos a + \sqrt{-1} \sin a)(\cos b + \sqrt{-1} \sin b)} =$$

The three expressions which the preceding equation contains * * * * are three symbolic expressions which cannot be interpreted according to generally established conventions and represent nothing real. * * * * The equation itself, strictly speaking, is inexact and has no meaning.

In 1849, however, in a paper *Sur les quantités géométriques*, in which he gives suitable credit to Argand, Français and others, he acknowledges :

In my *Analyse algébrique*, published in 1821, I was content to show that the theory of imaginary expressions and equations could be rendered rigorous by considering these expressions and equations symbolic. But after new and mature reflections the better side to take seems to be to abandon entirely the use of the sign $\sqrt{-1}$ and to replace the theory of imaginary expressions by the theory of quantities which I shall call geometric.

Having defined the term geometric quantity exactly as we now define the term vector and shown when two geometric quantities are equal, he continues :

The notion of *geometric quantity* will comprehend as a particular case the notion of *algebraic quantity*, positive or negative, and *a fortiori* the notion of *arithmetic quantity*. * * * We must further define the different functions of these quantities, especially their sums, their products and their integral powers by choosing such definitions as agree with those admitted when we are dealing with algebraic quantities alone. This condition will be fulfilled if we adopt the conventions now to be given.

Then follow the definitions called for, together with a treatment of the whole subject fully up to modern demands. Cauchy observes that a large part of the results of the investigations of Argand and others would seem to have been discovered as early as 1786 by Henri Dominique Truel, who communicated them about 1810 to Augustin Normand, of Havre.

In 1828 there appeared in Cambridge, England, a remarkable work by Rev. John Warren, entitled *A Treatise on the Geometrical Representation of the Square Roots of Negative Quantities*. Though this book has latterly received scant credit, its merits were fully recognized by De Morgan and acknowledgments of indebtedness were frankly made by Hamilton.

Throughout Warren's work the term quantity, like Cauchy's geometric quantity, indicates a line given in length and direction. Some of his definitions are as follows :

The sum of two quantities is the diagonal of the parallelogram whose sides are the two quantities. The first of four quantities is said to have to the

second the same ratio which the third has to the fourth; when the first has *in length* to the second the same ratio which the third has *in length* to the fourth, according to Euclid's definition; and also the angle at which the fourth is inclined to the third is equal to the angle at which the second is inclined to the first, and is measured in the same direction. Unity is a positive quantity arbitrarily assumed from a comparison with which the values of other quantities are determined. If there be three quantities such that unity is to the first as the second to the third, the third is called the *product*, which arises from the *multiplication* of the second by the first. If there be three quantities such that the first is to unity as the second is to the third, the first quantity is called the *quotient*, which arises from the *division* of the second by the third.

The fundamental laws of algebra as governing these quantities are established in their utmost generality with a rigor of reasoning that has probably not been surpassed. The author even goes so far as to deduce the binomial formula, to develop many series and to apply the methods of the differential and integral calculus to quantities of the class defined. In form Warren's work is intensely algebraic and fairly bristles with formulæ.

To sum up :

Caspar Wessel, in 1797, published the first clear, accurate and scientific treatment of directed lines in the same plane, as represented by quantities of the form $a + b\sqrt{-1}$, establishing the laws governing their addition, subtraction, multiplication and division, and showing these quantities to be of practical value in the demonstration of theorems and solution of problems; he also worked out a partial theory of rotations in space, so far as they can be decomposed into rotations about two axes at right angles.

Not very much later, 1799, Gauss indicated that he was in possession of a method of dealing with quantities of the form $a + b\sqrt{-1}$ which would consider them as equally possible with real quantities, but its fuller exposition was deferred till 1831.

Buée's paper of 1805 lays great emphasis upon $\sqrt{-1}$ as the sign of perpendicularity, but fails to give any satisfactory interpretation of the product of directed lines.

Argand's famous memoir of 1806 is hardly in danger of receiving too much credit. Though written after Wessel's paper there is not the slightest probability that Argand had any knowledge of the Norwegian surveyor, and, in fact, certain of his theorems are established less rigorously than by Wessel. Argand gave numerous applications of his theory to trigonometry, geometry and algebra, some of which are very noteworthy, especially his demonstrations of Ptolemy's theorem regarding the inscribed quadrilateral and of the fundamental proposition of the theory of equations.

The contributions of Français, Gergonne and Servois, 1813-1815, served to do away with some of the errors into which Argand had fallen and thus to give a clearer insight into the fundamental notions of the subject.

Though Warren's book of 1828 contains definitions differing but little from those of Wessel and Français and a notation which seems only a modification of that of Français, his generalized treatment of directed lines in the plane must be regarded as highly original.

Cauchy's work lay in the extension and development of the labors of his predecessors rather than in the introduction of new ideas.

Such were the beginnings of the study of the geometric representation of the imaginary which has led in modern times to the establishment of such great bodies of doctrine as the theory of functions on the one side and quaternions on the other, with the Ausdehnungslehre occupying a position between. Who can tell what the next century will bring forth?

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*EIMER'S EVOLUTION OF BUTTERFLIES.**

THE criticism, by Professor Minot, of the second part of Eimer's work, '*Arthbildung und Verwandtschaft bei den Schmetterlingen*', which appeared in SCIENCE at the beginning of last year (January 3, 1896, Vol. III., No. 53), gives me occasion to again explain Eimer's evolutionary theory, which, so far as I can see from Minot's article, has in many respects been misunderstood. It seems as though Minot were not well acquainted with Eimer's earlier works on the markings of animals, works in which questions of evolution were already discussed. And, as Eimer's present views on this subject are chiefly founded on the results of these earlier works, it is easy to understand why many assertions which need these results for their proof, seem incomprehensible to Minot. Minot calls Eimer 'an enthusiastic opponent of Darwin's theory of natural selection.' It is true that through his investigations on the markings of different groups of animals Eimer became more and more confirmed in his opinion that natural selection was of no moment for the origin of species. This view is expressed in the 'Butterflies,' with the distinct reservation (see p. 68) that he acknowledges the efficiency of natural selection in preserving and intensifying such characters as have previously been developed by other agencies to such an extent as to become useful to the organism in question. Eimer, then, occupies the same position that Mivart defended against Darwin (see 'Origin of Species', Germ. ed., 1876, p. 249 ff.) and he is a decided opponent of the teleological views spread by some of Darwin's followers rather than by the latter himself.

According to Eimer species originate by organic growth, a term first defined by him in his 'Origin of Species.' In the constitu-

* *Die Arthbildung und Verwandtschaft bei den Schmetterlingen*, II. Teil., von Dr. G. H. Th. Eimer, und Dr. C. Fickert. Jena, G. Fischer, 1895.

tional changes which organisms undergo during life in consequence of external influences, such as climate, food, etc., he sees the first agents that cause the development of new characters. These changes first reveal themselves as growth-phenomena. It is the struggle for existence that gives rise to selection from among these changes, that rejects or adopts. I must consider it a misrepresentation to call this view of the origin of species a bold hypothesis. It is merely the result of investigations which prove plainly that, in the more sensitive representatives of a species, external influences can and do produce individual variations, and that we find these as aberrations in contiguous districts and as species in those that are more distant. Eimer first mentions this thesis in his work on '*Das Variieren der Mauereidechse*'* and makes it probable by his observations; more striking proofs, however, are given in his work on the 'Evolution of Butterflies.' Our native horadimorph butterflies, such as *Vanessa levana* and *V. prorsa*, *Pieris bryoniae* and *napi*, make it sufficiently obvious that external influences are no indifferent factors in the formation of organisms. A variation of temperature to which the chrysalis is exposed produces, from the eggs of one and the same species, butterflies which differ so much in their external structure that for a long time they were held to be separate species. Dorfmeister† and Weismann‡

* Eimer: *Untersuchungen über das Variieren der Mauereidechse, ein Beitrag zur Theorie von der Entstehung aus konstitutionellen Ursachen*. Archiv. f. Naturgeschichte (und selbständige). Berlin, Nicolai, 1881.

† Dorfmeister: *Über die Einwirkung verschiedener während der Entwicklungsperioden angewandter Wärmegrade auf die Färbung und Zeichnung der Schmetterlinge*. Mitteilungen d. naturw. Vereins für Steiermark, 1864.

‡ A. Weismann: *Studien zur Descendenztheorie I. Über den Saisondimorphismus d. Schmetterlinge*, 1875.

showed by experiment—they let the chrysaliids of the *prorsa* generation develop at low temperature, those of the *levana* at high temperature—that both butterflies belong to one and the same species. Similar experiments have of late been made by Merrifield* and Standfuss† and have revealed still more astonishing phenomena in a great number of butterflies. They all tend to prove that the forms developed in heat or in cold respectively, always possess those qualities which characterize variations and nearly allied species of these butterflies living exclusively in warmer or colder climates. And not only the markings, but also the form of the wings and the whole configuration of the animal change. In his criticism Minot does not so much as mention these facts, which Eimer regards as a proof that the views on which his theory is based are correct; on the contrary, he particularly emphasizes that Eimer's theories are founded only on the study of the markings of animals and the geographical distribution of forms. It is true that, guided by the results of his earlier researches, Eimer regards these markings as the most characteristic signs of affinity between the various species.‡ And he considers as a further proof of the correctness of this assumption the results of the artificial development of butterflies in lower or higher temperatures in their relation to the geographical connection of forms.

* F. Merrifield: *Transactions of the Entomological Society of London*, 1893-94.

† Standfuss: Über die Gründe der Variation und Aberration des Falterstadiums bei den Schmetterlingen mit Ausblicken auf die Entstehung der Arten. Leipzig, 1894. The same: *Handbuch für Sammler der europäischen Grossschmetterlinge*. Zürich, 1891.

‡ Darwin also came to the same conclusion, as he says: "We shall hereafter see, especially in the chapter on Pigeons, that coloured marks are strongly inherited and that they often aid us in discovering the primitive forms of our domestic races." *Animals and Plants under Domestication*, Vol. I., p. 29. London, 1868.

Eimer's theory further materially differs from that of Natural Selection in its explanation of liabilities and tendencies to changes.

Natural selection presupposes the most varied liabilities to changes, in order to become efficient in the production of forms; Eimer, on the contrary, is of opinion that individuals can only follow prior determined, i. e., definite tendencies of evolution (not predetermined tendencies, as Minot wrongly understands). This 'Orthogenesis,' in opposition to Nägeli's view, does not always tend towards perfection, but often towards simplification and retrogression. In its rudiments this law shows itself in the markings of animals, inasmuch as the primitive form of longitudinal stripes becomes spots, transverse stripes, and uniformity of color. This rule, which Minot wishes to be 'proved, not proclaimed *ex cathedra*,' is followed, as is shown by Eimer's researches, by the ontogenesis and phylogenesis of reptiles,* birds,† and mammalia. Simroth‡ found this law confirmed in Limaces, I myself in the markings on the shells of marine gastropods.§ Although the physiological cause and, therefore, the necessity of this curious phenomenon has not yet been ascertained, yet, as it repeats itself in so many different groups of animals, it cannot be denied the importance of a fact. Hyatt's||

* Eimer: *Zoologische Studien auf Capri II.*, *Lacerta muralis corulea*. Leipzig, Engelmann, 1874.

† The same: *Die Zeichnung d. Vögel und Säugetiere*. Württemb. Naturwiss. Jahreshefte, 1883. The same: Über die Zeichnung der Tiere; *Zool. Anzeiger*, 1882, 1883, 1884, and in the *Zeitschrift Humboldt*, 1885-88. The same: *Mittheilungen über die Zeichnung der Säugetiere, Schmetterlinge u. Mollusken*. Tageblatt der 28. Versammlung deutscher Naturforscher u. Aerzte in Strassburg, 1885, p. 408.

‡ Simroth: Versuch einer Naturgeschichte der deutschen Nacktschnecken und ihrer europäischen Verwandten, *Zeitschrift f. wiss. Zoolog.* Bd. XLII.

§ Gräfin von Linden: Die Entwicklung der Skulptur u. der Zeichnung bei den Gehäuseschnecken des Meeres: *Zeitschrift f. wiss. Zoologie*. Bd. LIX.

|| A. Hyatt: *Genesis of the Ariidae*. Smithsonian

and Würtenberger's* works and my own investigations of the shells of Molluscs have shown that other morphological characteristics apart from the markings produce regular changes in a definite direction. Taking this into consideration I do not consider it a 'bold hypothesis' on Eimer's part, when he believes he has found a confirmation of his law of markings in the case of butterflies, for "any hypothesis which explains various large and independent classes of facts rises to the rank of a well-grounded theory." (See Darwin, *Animals and Plants under Domestication*. Vol. I., p. 8, 1868.) In the systematic part of his two volumes on 'Butterflies' Eimer shows how seemingly insignificant variations of the markings from the original form invariably develop into definite characteristics of new aberrations and species, the changes being dependent upon physiological conditions. It can therefore not be asserted that butterflies are subject to the most multifarious liabilities to change. The markings of *Segelfalter* and of Swallow-tails can be reduced to one common scheme, which, as the illustrations show, is most simply represented by the markings of *Papilio Podalirius*. This scheme of markings consists of eleven bands which extend over the wings in a fixed direction parallel to the axes of the body. They are called longitudinal bands and are always connected with certain veins of the wings. These eleven bands can undergo several variations. They can become broader and vanish altogether by means of lateral combination, become shorter in the direction from the abdomen or head, and sometimes quite disappear, or develop into single spots and form a transverse marking by

Contrib. to Knowledge, 1889. The same: Phyletic of an Acquired Characteristic. Proceedings of the Amer. Philosoph. Soc., Vol. XXXII., No. 143, 1895.

*Würtenberger: Studien über die Stammesgeschichte der Ammoniten, Leipzig, 1880.

means of dark colored scales which show themselves on the transverse veins of the wings. In this way the *Segelfalter*, as well as the Swallow-tails, develop new forms, which, from showing only slight aberrations from the original form in the beginning of the evolutional series, differ materially from it in the end. The same law which thus determines the evolution of the members of a group also determines that of the groups themselves. Each succeeding one begins its development at a somewhat higher stage than its predecessor. Variations which are an exception in the lower groups become the rule in the higher ones. This is the reason why the representatives of the first groups of the *Segelfalter* "have markings very similar to the original form, while the third group contains butterflies which closely resemble the Swallow-tails."

The primitive Swallow-tails have attained a much higher degree of development than the primitive *Segelfalter*, but still it is not difficult to recognize that, although they are not immediately allied to the *Segelfalter*, yet their development follows the same direction. The Swallow-tails still possess indications of a separation of bands, which in the *Segelfalter* have coalesced. Furthermore, fragments of markings which still occur in forms closely related to the Swallow-tails show that the development of their markings depends on the same conditions as those of the *Segelfalter*. It would lead me too far to describe in detail the directions of evolution which manifest themselves in the various groups. I will only mention that the tendency of the bands to broaden and to coalesce can be traced throughout the entire groups of *Segelfalter* and has produced almost melanotic forms in the group of *Asterias* of the Swallow-tails. Further, the shortening of the bands from abdomen to head is characteristic of both *Segelfalter* and Swallow-tails. In both groups the

bands become spots and combine into a transverse marking by the agency of dark colored scales on the transverse veins. If we neglect secondary differences of markings in the two groups of *Papilio*, we have to assume that they originated in complete independence of each other—a direct relationship cannot be proved—according to the same definite laws of development.

In entire groups as well as in single species, no matter whether they live in the same or in different districts, the law of a definite direction of evolution is shown in homogenesis, or independent similarity of evolution. As examples, Eimer cites the North American *Turnus* and the south European *Alexenor* (which is also found in Asia Minor), of *Segelfalter* the South American *Agisilaus*, *Protesilaus* and the European *Podalirius*.

The phenomenon of homogenesis is of importance as a proof that it is not geographical distribution in the sense of local separation on which the development of different directions of evolution depends.

This short exposition of the direction of evolution in the genus *Papilio* seems to me to show that it was not arbitrariness on Eimer's part to select *Papilio Podalirius* as the ancestral form of his group of butterflies. He has shown, by his study of the markings of one series of forms, that those of all its members can be reduced to one and the same scheme, and that aberrations from the forms which are nearest to this original scheme of markings vary so as to form transitions to nearly allied species, which again are connected with more distant species, and the conclusions drawn from the study of these phenomena are confirmed by the results of geographical distribution. This being so, I cannot understand how Minot can doubt that Eimer's assertions are correct.

Neither does Minot agree with the explanation of the sudden appearance of a

second perfectly dark-colored form of the feminine *Papilio Turnus* by 'development by jumps' (*Halmatogenesis*). This singular form of feminine *Turnus* called *var. Glaucus*, which occurs exceptionally in the North and regularly as a summer generation in the South of the United States, seems not to be connected by any transitions with the normal feminine animal. Minot, however, believes it possible that in former times transitional forms existed. It seems to me a matter of course that a highly developed form like *Papilio Turnus var. Glaucus* has to undergo several variations of markings during the chrysalis stage before it can leave it in its present form. But in comparison with the difference between the variation of another species and its original form, that between *Turnus* and *var. Glaucus* remains just as striking, whether we know that during the chrysalis stage forms of transition temporarily occur or that in former times forms existed which made the transition from the normal feminine *Turnus* to the *var. Glaucus* somewhat more gradual. As it at present appears, *var. Glaucus* is a form produced by *Halmatogenesis*. Eimer's theory necessarily leads to the conviction that qualities produced by external influences are transmitted to the descendants of those who have acquired them, an assumption for which Minot demands proofs. The experiments of Weismann on *Polyommatus phleas*, which are mentioned in the *Zoologische Jahrbücher*, 1895, *Abteilung für Systematik*, show that this transmission of qualities from their possessor to his descendants really occurs.

It is by no means every individual that undergoes a change through the influence of unaccustomed external influences. Several preserve the parental aspect. And as the parental characteristics were not from the beginning such as they are at present, but are, as is shown by experiment, the result of certain conditions, the transmission

to the descendant of these parental characteristics which have also been acquired is the clearest proof of the heredity of acquired characteristics.

In spite of all his objections to the theoretical part of Eimer's work, Minot allows that the 'Butterflies' are "valuable from the standpoint of the systematic entomologist, since his groups are natural ones and his grouping of the species is in the main correct."

In his grouping of the butterfly species Eimer was guided by those laws which his study of the markings of other groups of animals had caused him to regard as the general rule, and which he therefore considers himself entitled to apply hypothetically to butterflies. The grouping of species being admitted by Minot to be natural, this is sufficient proof of the correctness of those theories which this grouping presupposes. In designating those groups as natural ones in which longitudinally striped forms develop into spotted, transversely striped and unicolored ones, Minot acknowledges the law of evolution of markings in its full significance.

Darwin, himself, in his 'Origin of Species,' employs similar proofs to show that the same groups of pigeons are descendants of *Columba livia*. Their phylogenetic connection is to him proved by the fact of elements of the markings of *Columba livia* appearing in the plumage of our tame pigeons.

The ontogenetic development of those groups of animals the markings of which Eimer has studied is to him a valuable argument for the correctness of the law laid down for their phylogenesis. Similar investigations made by E. Haase on the evolution of the markings on the wings of the chrysalis of *Papilio Podalirius*, in so far as his limited materials permitted decisive conclusions, completely confirm Eimer's assertions.

These and other researches on the same

subject led me to make similar investigations, the results of which I am about to publish. They furnish the best proofs for the laws found by Eimer. My specimens showed that not only single characteristics develop in the way described by Eimer, but that the markings of *Papilio Podalirius* or *Machaon*, as a whole, undergo an evolution in which the degrees of *Alebion*, *Glycerion* or the *Turnus* group are clearly distinguishable.

It would be of great interest to investigate the American forms of *Papilio* in order to see whether Eimer's 'bold hypotheses,' as Minot calls them, apply here. On the basis of arguments which have hitherto been considered customary and convincing in biology, I believe I have shown that Eimer far from rejecting Darwin's theory as a whole, because 'it does not explain the origin of variations.' He knows as well as Minot that Darwin does not even attempt an explanation of their origin. As, however, the theory of the origin of species demands an explanation of the origin of new characters, Darwin has not, as Eimer shows, explained that which he wished to explain. Eimer, on the contrary, shows in the 'Butterflies' how new qualities develop; he explains the causes of their formation and traces the laws of their development. This necessarily led to his well founded theory of the origin of species by means of variations and their propagation. The arguments contained in the 'Butterflies' must convince anybody who examines them somewhat more closely than Minot, that, as Eimer shows, variations and, therefore, the origin of species do not take place arbitrarily in the most varied, but according to Orthogenesis in a few absolutely definite, directions, not influenced by any sort of natural selection and without any reference to teleology. Eimer's theory of orthogenesis, proved as it is by facts, certainly negatives the function of

natural selection as a transforming factor, but acknowledges its preserving and intensifying power. This is the only concession that can be made to the theory of natural selection as long as the results of Eimer's investigations have not been refuted by facts, not, as heretofore, by words. Till then, I believe, one cannot deny to Eimer's work the appreciation contained in Minot's introductory sentences: "If Professor Eimer's claims are correct, his researches mark one of the great epochs of biological discovery."

I wish to state that this is merely a preliminary exposition of Eimer's views, intended for rectifying the erroneous judgment expressed by Minot. Eimer's work on organic evolution (Macmillan, 1889) gives a detailed account of his theoretical views and of the facts on which they are based. His work on Butterflies, which was criticised by Minot, serves to furnish further corroboration of the theory advanced in the above work on evolution. In his lecture at Leyden he has also given a complete exposition of his ideas in their relation to the theory of selection and of Weismannism; against the latter Eimer takes a most decided stand (see 'Extract from Comte Rendu des Séances du 3^{me} Congrès international de Zoologie, Leyde, 16-21 Sept., 1895'). This lecture includes the programme of Eimer's most recent exposition of 'Orthogenesis' embodied in a work that is just about to appear.

COUNTESS DR. M. VON LINDEN.
ZOOLOGICAL INSTITUTE, HALLE.

THE Countess von Linden's article presents the arguments in favor of Eimer's theory. A reply seems unnecessary and others will judge of the value of the theory. Eimer's earlier papers I knew; whether I understood them or not I cannot decide. All of Eimer's evidence is essentially that he asserts that of a group of living species a

certain form or certain forms are ancestral types. If one denies that assertion Eimer cannot prove that it is correct, but unless he proves it his deductions remain hypotheses. The reader is asked to consider whether Countess von Linden offers proof that a certain species in any given case is the ancestral race.

For the sake of a fair discussion I am glad that the preceding communication from Professor Eimer's assistant appears in SCIENCE.

CHARLES S. MINOT.

*PROGRESS OF PROFESSOR KITASATO'S INSTITUTE FOR INFECTIOUS DISEASES AT TOKIO.**

AMONG the changes in the general condition of Japan, due to the introduction of Western civilization, one of the most noteworthy is the entire revolution in the system of medicine; the old Chino-Japanese school has been superseded by the scientific system of the West, and the striking feature of the new medicine in this empire is the ascendancy of the bacteriological element. The center of this movement is seated at the 'Institute for Infectious Diseases,' directed by Dr. Kitasato.

To Mr. Fukusawa belongs the credit of having initiated the introduction of this branch of medical science into this country by building, at his own expense, a laboratory for Dr. Kitasato, upon the latter's return from Germany in 1892. I do not mean to ignore what has been done at the University and elsewhere; I only emphasize the great impetus that the study of the micro-organisms has enjoyed since the establishment of the above mentioned laboratory. Subsequently the Institute became connected with the 'Sanitary Society of Japan.' The ensuing year the Imperial Diet

* This article was prepared at the request of the Editors. Dr. Nakagawa is a graduate of Princeton University.

granted the sum of 20,000 yens (\$10,000) for the building and equipment of the Institute, and also yearly the subsidy of 15,000 yens, which was to be continued for three years. At the expiration of the term the same subsidy has been renewed for the same number of years. Thus the Institute has no relation with the Imperial University of Tokio and is directly under the patronage of the Minister of the Interior.

The work of the Institute is divided between the scientific and clinical departments; the scientific department is subdivided into the laboratory for original researches and the didactic branch for the postgraduate course in practical bacteriology.

(a) *Laboratories for Original Researches.*

It is here that Dr. Kitasato continues his investigations, and I take this opportunity to recapitulate some of the more important reports issued from his laboratory.

(1) *Tsutsugamushi.*—This malady, which is endemic in certain parts of this country, presenting the clinical feature resembling that of the typho-malarial fever, has been ascertained to be the pathological condition due to the parasitic invasion of the red blood corpuscles analogous to that which obtains in malaria. Moreover, the plasmodia of tsutsugamushi is described as being morphologically very nearly related to that found in malaria, but differing from the latter parasites in this important respect: viz., that the tsutsugamushi parasites are refractory to all the staining procedure now in use.

(2) *Bacillus Pestis.*—The discovery of the plague bacilli is too well known to need mentioning in this connection were it not for the fact that it seems to be utterly unknown to the world that the bacilli claimed to be the specific germ of the plague by Dr. Yersin is absolutely different from that described by Dr. Kitasato. Dr. Kitasato's bacilli are almost exactly like those of chicken

cholera (in shape), i. e., each bacillus presents the appearance of a pair of diplococci, and is, as a rule, considerably smaller than Dr. Yersin's bacillus. Kitasato's bacilli can be stained according to Gram's methode, while the other is decolorized by the regular procedure. Kitasato's bacillus is surrounded by a distinct capsule which is wanting with Yersin's. Moreover, Kitasato's bacilli are motile, but Yersin's bacilli are not. There are thus at present two distinct bacilli held to be the aetiological factor of the disease in question. It is to be hoped that the members of the commission sent out to Bombay will help to clear up the confusion.

(3) *Anti-diphtheritic serum.*—The preparation of the serum has been carried on in this Institute previous and up to the opening of the Imperial Government Serum Institute, in June, 1896. I might mention in this connection that Dr. Kitasato is the chief advisor of the Serum Institute.

(4) *Anti-cholera serum.*—I have had occasion elsewhere to make a brief report of Kitasato's work on this subject (*Brit. Med. Jour.*, July, 1896). I shall only mention here that the result was in so far encouraging that it justifies making further trials of this remedy in the future epidemics. Neither shall I enter into detail concerning the experimental part of the work in which Dr. Kitasato seeks to prove the anti-toxic property of the cholera-serum; suffice it to say that the conclusion he has reached is at variance with that of the Berlin school.

(5) *Lepra.*—Dr. Kitasato has been engaged in the most thoroughgoing investigation into the treatment of leprosy. It is reported that he is in possession of the remedy which goes under the name of 'Leprine,' though I am unable to say that its preparation is, in any way, analogous to that of tuberculin, as its name seems to suggest. It is expected that Dr. Kitasato will favor the world by publishing his full report in the near future.

(6) Investigations concerning the typhoid and erysipelas serums, as well as various other researches in all the fields of micro-biology, are being pursued by the Professor himself, as also by the assistants under his supervision. There are 6 assistants and nearly 10 'extra-ordentliche' assistants.

The studio for micro-photography has recently been built and is equipped with Zeiss's complete apparatus.

The library, though in its infancy, contains most of the works on infectious diseases, bacteriology and hygiene, and is supplied with the medical periodicals in the English, French, German, Italian and Japanese languages. I take this opportunity of acknowledging the receipt of the following official publications from America: U. S. Department of Agriculture, Bureau of Animal Industry; Bulletins U. S. Treasury Department, Marine Hospital Service, Health Reports, etc.; City of Brooklyn, Department of Health, Annual Report. We should be glad to receive more of the American publications.

(b) *Practical Course in Bacteriology.*

The utility of the knowledge of micro-organisms being admitted, it was deemed desirable to give a practical course of bacteriology for the benefits of the licentiates in medicine. The first course was given in March, 1894. The course is of three months' duration and is conducted by Professor Kitasato, who gives a series of lectures on the pathogenic bacteria. The assistants take their turn and serve as demonstrators. The laboratory for instruction accommodates 50 students and is provided with all necessary appliances. Over 200 physicians have gone through the course. It is with great pleasure that we mention in this connection that the American naval surgeon and an English naval surgeon have availed themselves of the facilities of the Institute and have pursued their investigations for a considerable length of time.

(II.) THE CLINICAL DEPARTMENT.

The wards in all are capable of holding 50 patients. The admission is limited to cases of contagious diseases (except cholera and smallpox). Diphtheria, tuberculosis, typhoid, tetanus and relapsing fever are the principal maladies on the list. I may mention in this connection that 180 cases of leprosy have been treated in the out-patient department with the injection of 'Leprine,' and 4 cases of complete recovery, beside several cases of improvement, have been reported. The diphtheria statistics show a mortality of 9.44%.

A. NAKAGAWA.

INSTITUTE FOR INFECTIOUS DISEASES, TOKIO.

NINTH ANNUAL MEETING OF THE ASSOCIATION OF ECONOMIC ENTOMOLOGISTS,
DETROIT, MICH., AUG. 12-13, 1897.

THE Association met in room 212, Central High School building, immediately following the adjournment of Section F. Thirteen active members were present, together with many visitors, prominent among the latter being Dr. C. A. Dohrn, Professor E. B. Poulton and Dr. C. S. Minot. The attendance for the four sessions averaged about 35. The address of the retiring President, Professor F. M. Webster, Wooster, Ohio, treated of 'The Present and the Future of Applied Economic Entomology in the United States,' and contained, among other very interesting features, an admirable tribute to the value of the systematist and a somewhat caustic criticism of the 'species maker,' helpful suggestions for the experiment station worker, and a very frank discussion of the unfortunate results which attend the attempts sometimes made to combine politics and science.

The following were elected to active membership: G. B. King, Lawrence, Mass.; Gerald McCarthy, Raleigh, N. C.; E. P. Felt, Albany, N. Y.; A. F. Burgess, Mal-

den, Mass.; W. B. Barrows, Agricultural College, Michigan; R. H. Pettit, Agricultural College, Michigan; W. S. Blatchley, Indianapolis, Ind.

The following were elected foreign members; Claude Fuller, Richard Helm, both of Perth, West Australia. These additions increase the members of this Association to 93 active and 31 foreign members.

The following papers were read and discussed: 'Additional Observations on the Parasites of *Orgyia leucostigma*,' 'Temperature Effects as Affecting Received Ideas on the Hibernation of Injurious Insects,' 'A Valuable Coccid,' 'Notes on the Common House Fly,' L. O. Howard; 'Notes on Certain Species of Coleoptera that attack Useful Plants' (abstract), F. H. Chittenden; 'An Experience with Paris Green,' T. D. A. Cockerell; 'Insects of the Year,' E. A. Onerod; 'A Fungus Disease of the San Jose Scale,' P. H. Rolfs; 'The San Jose Scale in Michigan,' 'A Malodorous Carabid, *Nomius pygmaeus*,' W. B. Barrows; 'A Study of Lepidopterous Insects at Light and at Sugar,' 'Vernacular Names of Insects,' C. P. Gillette; 'A Study of the Possible Origin and Distribution of the Chinch Bug,' F. M. Webster; 'Notes on Cape of Good Hope Insects,' C. P. Lounsbury; 'The Giant Cactus and Its Fauna,' H. G. Hubbard; 'Insects of the Year in Ohio,' F. M. Webster-C. W. Mally; 'On the Preparation and Use of Arsenate of Lead,' A. H. Kirkland. A number of papers, the authors of which were not present, were read by title and will be included, probably, in the published proceedings of the Association. Among these papers were the following: 'Notes on Insecticides,' 'The Peach Twig Borer, *Anasina lineatella*,' C. L. Marlatt; 'Ledra perdita vs. Centruchus liebeckii,' F. W. Goding; 'Notes sur les Insectes Nuisibles observés en Algérie et en Tunisie pendant l'année 1896-97,' 'Notes sur les Insectes Nuisibles observés en France,' Paul

Marchal; 'Notes on Injurious Insects of Norway and Sweden,' W. M. Schoyen.

Several resolutions were passed, among which were (1) a resolution requesting the publication of the proceedings as a bulletin of the Division of Entomology, U. S. Dept. of Agriculture and (2) expressing familiarity with the efforts of the State of Massachusetts to exterminate the gypsy moth and commending the results already accomplished.

The election of officers resulted as follows: President, Herbert Osborn, Ames, Iowa; First Vice-President, Lawrence Bruner, Lincoln, Neb.; Second Vice-President, C. P. Gillette, Ft. Collins, Colo.; Secretary-Treasurer, C. L. Marlatt, Washington, D. C.

The next meeting of the Association will be held at Boston, Mass., August 19-20, 1898.

A. H. KIRKLAND,
Secretary pro tem.

CURRENT NOTES ON ANTHROPOLOGY.

THE ANCIENT SLAVONIC TYPE.

THERE prevails considerable uncertainty as to the appearance of the ancient Slavs. Professor Lubor Niederle, of Prague, however, in a recent work, and also in *Globus*, No. 24, advances what seems sufficient reasons to pronounce them to have been blonde and dolichocephalic. He quotes the earliest authentic references in classical authorities, all of which refer to the fair complexion and reddish blonde ($\xi\alpha\theta\delta\varsigma$) hue of the Slavic peoples. In these respects the descriptions are the same as of the early Goths.

It is true that at present, and also in many interments of ancient dates, brachycephalic skulls are found in considerable numbers; and persons with dark complexions and dark hair are numerous in Slavic countries. Professor Niederle explains this change of type by two agencies, intermixture with other stocks, and by civilization.

About the latter he writes: "We cannot demonstrate the connection, but there is a striking parallelism between advancing civilization and the gradual increase of the skull in width." This is an interesting statement, and it is to be hoped that Professor Niederle will make it the subject of a special study in the future.

THE LANGUAGE OF THE MAMS.

The Mams lived in the northwestern part of Guatemala and enjoyed an advanced indigenous civilization. Their capital was Zakeleu, the White Land, meaning the place of culture; for in all the Maya dialects white is a metaphorical expression for civilized conditions. By some the Mams have been held to be the earliest of the Mayas to become sedentary and city builders. Their ancient native name was Zak-lohpakap, the White Cultivators.

A vocabulary of their tongue was printed by Father Reynoso, at Mexico, in 1644, but is now so scarce that it is inaccessible to students. The Comte de Charencey has, therefore, conferred a favor on Americanists by republishing it in the *Actes de la Société Philologique*, Tome XXV. It contains nearly three thousand words, and offers ample material for comparisons with the other dialects of the stock. It is closely akin to the Quiche, and is still spoken in a number of villages. The volume may be had from C. Klincksieck, 11 Rue de Lille, Paris.

D. G. BRINTON.

UNIVERSITY OF PENNSYLVANIA.

NOTES ON INORGANIC CHEMISTRY.

In 1887 Professor Chroustchoff announced the discovery of a new element in the monazite sand of North Carolina, to which he gave the name 'russium.' This discovery has not been confirmed by any other chemist, but, induced by the supposed discovery of 'lucium,' Professor Chroustchoff has again gone over his work, pub-

lishing a short report in the *Journal of the Russian Chemical Society*. According to *Nature* he has from 25 kilos of rare earths extracted 35 grams of russium. It has an atomic weight of 70.5 and its spectrum is characterized by a group of green and violet lines. He also claims to have resolved cerium into five components, differing in physical properties, and having atomic weights respectively of 138, 140, 142, 146 and 156.5. He also finds, in addition to Auer's neodymium and praseodymium, a third new constituent of didymium to which he gives the name glaukodymium. A detailed account of his work is promised at an early date.

In the last *Berichte*, W. Hentschel gives an account of further investigations on the chloride of nitrogen, in which he finds the compound normally formed to have the formula NCl_3 , confirming the work of Gattermann and of Balard. He also finds that this compound can take up more chlorin until its composition seems to be NCl_5 , but this is really a solution of chlorin in the chloride of nitrogen. His method of forming this exceedingly explosive and dangerous compound is to bring together solutions of ammonium chlorid and sodium hypochlorite, and dissolve the chlorid of nitrogen formed, which partly separates out and partly remains in solution, in benzine.

In the *Pharm. J. Trans.*, C. H. J. Warden describes the method used in the Calcutta Medical Depôt for the production of a pure silver nitrate from coin silver. The silver used contains copper and is dissolved in nitric acid and a portion of the silver nitrate crystallized out in the usual way. As soon as the mother liquor is so concentrated that the silver nitrate crystallizing out is contaminated with copper it is evaporated to dryness, finely powdered and placed in a glass funnel stopped by an asbestos plug. It is then washed with pure concentrated

nitric acid until perfectly white. The copper nitrate is very easily soluble in the nitric acid, while the silver nitrate is almost wholly insoluble. Any trace of silver dissolved by the nitric acid can be recovered by treating with salt. This is by far the simplest method proposed for obtaining pure silver salts from coin or plate, and deserves trial in our laboratories.

H. TRYLLER describes in the *Berichte* a new turbine for laboratory use, which lays claim to the advantages of steadiness, noiselessness and economy of water. To the axle is attached a circular piece of wire gauze, rotating in a thin cylindrical space. The jet of water strikes the edge of the gauze at a tangent and escapes by a pipe in the center opposite the end of the axle. A speed of four thousand revolutions is easily attained. The turbine is to be manufactured by M. Koehler and Martini, of Berlin.

J. L. H.

SCIENTIFIC NOTES AND NEWS.

THE meeting of the British Association at Toronto has proceeded in accordance with the program. The members in attendance, about 1,200 in all, have been received with great hospitality, and many important papers have been given before the sections. The meeting is still in progress as we go to press, and we shall defer an account of the proceedings until next week.

THE British Medical Association will meet in Edinburgh in 1898, under the presidency of Professor T. Grainger Stewart.

ACCORDING to the latest lists about 5,000 members had expressed their intention of attending the 12th International Medical Congress meeting this month in Moscow; about half of the number are Russians, 800 are from Germany, 600 from Austria, 500 from France, 250 from England and from Italy, and 100 from America.

THE sixty-ninth meeting of German Men of Science and Physicians will, as we have already noted, be held at Brunswick from the

20th to the 25th of September. The social arrangements begin on the preceding day with a reception, a banquet and an exhibition of sports. The first general meeting opens on the 20th with the reports of officers, followed by two addresses, one by Professor Richard Meyer, of Brunswick, on the relations between chemical research and technical chemistry; the other by Professor Waldeyer, of Berlin, on fertilization and inheritance. At the second general session Professor Orth, of Göttingen, will speak on medical instruction and the practice of medicine, and Dr. Hermann Meyer, of Leipzig, on central Brazil. Several joint meetings of the sections have been arranged, one of special interest being a discussion of scientific photography in its applications to the natural sciences and to medicine.

THE Scientific Society of Argentina, says *Nature*, is organizing a Congreso Científico Latino Americano, to be held at Buenos Ayres in April next, in commemoration of the twenty-fifth anniversary of its foundation. The Congress will be under the patronage of the President of the Argentine Republic and the Ministers of Justice, Foreign Affairs, and Public Instruction. There will be seven sections, dealing respectively with exact sciences (pure and applied mathematics, astronomy, geodesy and topography), engineering, physics and chemistry, natural science, medical sciences (including hygiene and climatology), anthropology and sociology.

WE noticed sometime since the appointment of a committee to investigate the condition of the Coast and Geodetic Survey. This committee has now presented a report which will not be made public. The *Washington Star*, however, states that it is practically decided that a successor to the present Director of the Survey will be appointed, and that the selection will be made without reference to political considerations and on the grounds of scientific standing.

PROFESSOR C. B. HOWES, writing Dr. Thurston to inform him of the condition of the work of the Huxley Memorial Committee, states that the statue is now in progress, in the hands of Mr. Ford, the sculptor, and promises to be most excellent. It is to be a seated figure in a gown,

to be placed at the bottom of the steps in the Hall of the Natural History Museum leading up to the statue of Darwin. It is in white marble. The design for a medal for the Royal College of Science is thought admirable, and the medal is in preparation. It is further possible, if subscriptions continue, that a medal may be instituted, open to the world of biologists, and awarded by the Royal Society. The Messrs. Macmillan, as a memorial, also, are publishing a fine edition of Huxley's scientific papers; the first volume being now well in hand. There are on the list many subscriptions from America and it is not too late for others to be sent.

THE monument to Darwin to which we have several times referred was unveiled on August 10th. It is in his native town of Shrewsbury and in front of the school which for nine years he attended. The monument, the work of Mr. Horace Montford, represents Darwin seated in a chair holding some manuscripts from which his face is turned as if deep in thought, while at the foot are a number of volumes representing his finished works.

DR. VICTOR MEYER, professor of chemistry at the University of Heidelberg, died at Heidelberg of apoplexy on August 8th, aged 49 years. Meyer filled chairs of chemistry at Stuttgart, Zurich and Göttingen and finally succeeded Bunsen at Heidelberg in 1889. His work was in organic chemistry, more especially relating to the nitro-compounds and the vapor density of volatile compounds.

WE regret also to record the deaths of M. Quantin, assistant in the taxidermic laboratory of the Paris Museum of Natural History, and of Dr. W. Petzold, a writer on geography and astronomy.

WE learn from *Cosmos* that the new buildings of the Paris Museum of Natural History have not been completed as soon as was expected, the work of construction having been stopped for three months owing to the delay in voting funds for its completion. Work has, however, now been resumed and it is hoped that the galleries will be open to the public by the beginning of next year. The lower floor contains the collections of comparative anatomy which are being arranged under the direction of MM. Filhol and

Jarvis. The collections of anthropology and paleontology are being put in order on the upper floor. The collections have hitherto been badly arranged in crowded quarters, but will now be exhibited to great advantage. New catalogues giving full details are also being prepared.

AN exhibition has been opened in the zoological galleries of the Paris Museum of Natural History containing the collections in natural history made by M. Chaffanjon on his expedition to Siberia and Central Asia.

AN exhibition of navigation instruments was opened in London on August 5th, intended especially to illustrate the progress that has been made in the art of navigation during the Queen's reign. There are in all about two hundred exhibits including a sextant by Bird, said to have been used by Captain Cook, lent by the Royal Astronomical Society, Lord Kelvin's deflector for adjusting the compass, his sounding machine and other instruments of historical or scientific interest.

WE learn from *Die Natur* that the committee for the introduction of the produce of German colonies held its general meeting in Hamburg, recently. The committee has founded a journal called *Der Tropenpflanzer*, and has established in Berlin a permanent exhibition of colonial imports. The committee offers prizes for the development in the African colonies of new resources, such as the making of wine, the cultivation of coca and quinine, the production of gum arabic, etc.

THE Hungarian government has completed the necessary arrangements for the construction, without delay, of a subway beneath the Danube at Budapest on the same principle as that of the new Blackwall tunnel under the Thames in London.

A TELEGRAM from San Francisco states that Commissioner-General Herman, of the United States Land office, has arrived there for the purpose of conferring with Professor Hilgard and other members of the State Forestry Commission upon the subject of the forest reserves, of which about 6,000,000 acres are located in California.

THERE has been established in Switzerland a weather bureau. A dispatch is sent each evening from Zurich giving the weather probabilities for the next twenty-four hours. The predictions are based on data received from the principal meteorological stations of Europe combined with experience of local conditions. The dispatch is further distributed by telephone to those communes prepared to subscribe 10 frs. per month for the service.

THE Royal 'Institut für Pflanzen Physiologie und Pflanzen Schutz,' in Berlin, offers to give, without charge, information and advice regarding diseases and injuries of cultivated plants. It is also prepared to send agents to examine the plants without charge beyond the railway ticket which, in certain cases, will also be paid by the Institute.

AN International Conference of Legal Medicine convened at Brussels on August 2d. It was welcomed by the Belgian Minister of Justice, and Dr. Veleminckx, the Honorary President of Committee of Organization, gave an account of preceding conferences. A number of topics were discussed concerning the relations of medicine and law—among them the treatment of insane criminals, regarding which a series of recommendations was passed by the Congress.

THE Eighth Annual Congress of French-speaking Neurologists met at Toulouse on August 2d. Addresses were made by Dr. Ritti and Dr. Labéda, on Esquirol, who was born at Toulouse, and Pinel, who was born near by, as the inauguration of memorials to be erected in their memory. Pinel and Esquirol, as is well known, were leaders in the reforms in the treatment of the insane. Before their time it was usual to treat the insane as intermediate between criminals and wild animals. They first showed that insanity is a disease, and in many cases a curable disease.

WE noted last week the loss, in the shipwreck of the *City of Mexico*, of the collections and apparatus of the zoological expedition sent by Columbia University to Alaska. Word has just been received by mail that the party lost all the results of their season's work. They left Sitka in the *City of Mexico*, of the Alaska S. S.

Co., on August 4th, taking the outside passage. At 4:20 a. m. on the 5th, in a heavy fog, the vessel attempted to enter Queen Charlotte Sound, through Dixon's Channel, and ran upon a reef known as Devil's Rock, sinking in two hours. The crew and passengers were transferred to life boats and after seventeen hours of exposure reached the Indian village at 11 p. m., where they were hospitably cared for until the arrival of the *City of Topeka*, three days later. The Columbia party lost all their collections, drawings, notes and apparatus, excepting three microscopes. They will reestablish the old station at Port Townsend, Puget Sound, for the remainder of the season.

M. ROBERT WURTZ, professor at the Paris School of Medicine, one of the leading French bacteriologists, has been chosen for a mission in Abyssinia. He will go to Adis Abeba, where, after having organized a department of vaccination, he will study the rinderpest and similar infectious maladies.

THE steamer *Belgica*, with the Gerlache Antarctic expedition on board, sailed from Brussels on August 16th. The Belgian Chamber of Representatives has made an additional appropriation of 60,000 frs. for the expedition.

A MESSAGE has been received from Turnavick, on the coast of Labrador, dated July 28th, stating that the steamer Hope, with Lieutenant R. E. Peary's expedition abroad, had touched there that day and sailed again on its way to Greenland. All on board were well.

A SERIOUS epidemic of small-pox is feared at Montreal. The city has been divided into twenty-four districts, and there will be a house-to-house vaccination.

DR. MARTEN, chief of Dr. Roux's laboratory of the Pasteur Institute, has been awarded an honorary gold medal by the French government for his work in epidemiology.

SEÑOR CANOVAS, by his will, has left to the National Library, at Madrid, a collection of 30,000 books, many of which are very rare.

A BUILDING for a free library and historical society, to cost \$20,000, has been given by Mr. Spalding, of Chicago, to Athens, Pa., his native town.

AN explosion occurred recently in a laboratory at Saint Michael-de-Maurienne, where carbide of calcium was being manufactured. The building was destroyed and one workman was killed and three others were seriously injured.

THE unpublished journals of the great naturalist Audubon, written in French, are being translated for publication in English by his granddaughter, Miss Maria Audubon.

GINN & CO. announce that they will publish at once 'Stories of Insect Life,' by Professor Clarence M. Weed, of the New Hampshire College of Agriculture and Mechanical Arts. The book is designed to give information to the child regarding the lives of the insects, and to stimulate pupils to fuller observation of insects out-of-doors.

THE trustees of the Boston Public Library have authorized the publication, in their bulletins, of an exhaustive 'Bibliography on the Anthropology and Ethnology of Europe,' prepared by Professor William Z. Ripley, of the Massachusetts Institute of Technology, lecturer in anthropo-geography at Columbia University. This list of references will include about 1,500 titles, taken in every instance from the original sources. It embodies the raw materials of the papers on the Racial Geography of Europe now appearing in successive numbers of the *Popular Science Monthly*, afterward to be published in book form. Every precaution has been taken to insure completeness and accuracy; most of the living authorities will have corrected and supplemented the lists of their own works in proof. The bibliographical systems of Minot and Wilson will be employed, with a complete subject index. A special feature will be the reference to original maps, whether linguistic, somatological or ethnographical. It is worthy of note that practically all of the titles in this recent field of investigation are upon the shelves of the Boston Library, proof positive of the possibilities for research from original sources which are now afforded by our great American collections.

WE are glad to welcome a new edition of the 'Dynamic Sociology,' of Professor Lester F. Ward, published by the Appletons. The first edition, issued in 1883, was very fully reviewed

in four articles included in the second volume of this JOURNAL, and no material changes have been made in the present edition. There is much to be said for not attempting to recast a work that represents a given epoch in the history of a new science. The further development of the author's views on psychology have been given expression in a separate volume (the 'Psychic Factors of Civilization,' 1893), and this is a better plan than re-writing a standard book. An interesting preface to this edition of the 'Dynamic Sociology' notes that fourteen years ago, when the work was first published, the word *sociology* was used but rarely; there were but few books on the science, no journals, and no university chairs. Now all is changed; the word is on the lips of everyone, and the science, if given as wide a range as Professor Ward's book, bids fair, as he says, to become the leading science of the twentieth century. The preface gives some account of the suppression of the Russian translation of the book, which was widely commented on in the daily papers several years ago. The suggestion is made that the title suggested socialism and dynamite to the Council of Ministers, a very dangerous combination from their point of view. A Polish translation appears also to have been suppressed, but four Russian translations of the 'Psychic Factors of Civilization' have been made.

PROFESSOR BAILEY'S 'Principles of Fruit Growing' (The Macmillan Co) is both practical and scientific. As all that the author writes—and it is not little—the book is worth reading, both by the practical gardener and by the student. After an introduction covering the kinds of fruits, the geography of fruit growing and its methods, chapters are devoted to location and climate, the tillage of fruit lands, their fertilization, their planting and their care, followed by chapters on disease and insects, and on harvesting and marketing. Professor Bailey makes many acute remarks, as when he calls spraying 'insurance' and gives as one of its uses 'waking up the horticulturist.' This volume is the fifth in this 'Rural Science Series,' edited by the author of this volume, which has fulfilled the promise of the publishers to be 'readable, simple, clear-cut, practical, up-to-date, and thoroughly scientific and reliable.'

WE have received from W. B. Saunders, Philadelphia, a bulky volume by Drs. George M. Gould and Walter L. Pyle, entitled "Anomalies and Curiosities of Medicine: Being an encyclopedic collection of rare and extraordinary cases, and of the most striking instances of abnormality in all branches of medicine and surgery, derived from an exhaustive research of medical literature from its origin to the present day, abstracted, classified, annotated and indexed." We should scarcely suppose that the compilation of this volume would repay the labors of the compilers and the costs of publication. A miscellany like this can scarcely be regarded as a contribution, such as Geoffroy Saint-Hilaire made, toward an explanation of the formation of monstrosities in its relation to zoological theory. Still the study of variations is of the utmost importance for zoology, and extreme cases of human abnormality may prove useful to the student of the theory of evolution. The cases given in the work are treated critically, full references being given and a fairly conservative attitude being adopted. But one modern instance is worth more than many old saws, and it is rather a contribution to folk-lore than to medicine to relate stories, qualified as incredible, such as that of Countess Margaret and her 365 infants.

THE fifty-eighth anniversary meeting of the Fellows of the Royal Botanic Society was held on August 10th, in the Society's gardens at Regent's Park, Mr. C. Brinsley Marlay presiding. According to the report in the London *Times* six new Fellows were elected and eleven candidates were nominated for election at the next meeting after the vacation. The annual report of the Council to the Fellows stated, among other things, that tentative arrangements had recently been made for taking visitors round the gardens by members of the staff to point out objects of special interest. Free tickets had been granted during the year to about 800 students. About 50,000 specimens of plants had been given for educational purposes. The Council had decided to open a school of practical gardening and to hold examinations and grant certificates for gardeners.

The new school had already been officially recognized by the Technical Education Board, which was sending pupils to attend its classes and had voted an annual grant of £100 to the Botanic Society in aid of the scheme. The number of Fellows on the books had risen from 1,700 in 1887 to 2,000 in 1897. The report having been presented, a discussion followed in which Sir Blundell Maple, M. P., proposed that the Society should build in the gardens a club-house to which the Fellows could have access. He volunteered to lend the Society a sum of £3,000 for this purpose, the money to be repaid by easy instalments. He anticipated that such a club would be a large source of income to the Society, and he added that if it should eventually prove to be a loss the loss should be his. Eventually the report was adopted unanimously. The chairman announced that the promise of a new lease of the gardens, to commence on the termination of the present one, had been definitely given by her Majesty's Commissioners of Woods and Forests for a fresh term of 31 years, and that the Society's outlook was now most promising.

THE research scholars of the British Medical Association (the scholarships being of the value of \$750 each) have handed in their reports. Dr. J. B. Leathes has been engaged in a research into the nature of mucin-like proteids contained in ovarian cysts. Dr. J. S. R. Russell has been studying the tracts of the medulla oblongata and the cervical nerves. Dr. Swale Vincent has been studying the physiology of the suprarenal capsules.

ACCORDING to the *British Medical Journal* the new State Institute for researches with Röntgen rays, or 'actinography' (as the new term runs) has been opened under the direction of Professor Grunmach. It is close to the Charité Hospital and its clinical institutions, and has every convenience for the transport of severe cases. Needless to say, the Institute is furnished with all the newest appliances; it contains a laboratory, a lecture theatre, photographic rooms, and a room where the patients are examined according to the usual methods before being subjected to the X-rays. In the first week after the opening of the new Institute,

two of the rare cases of inversion of the viscera were sent from the Charité, actinography revealing the inverted displacement of the organs, their size and motions, with the greatest distinctness.

PROFESSOR GOTCH, Waynflete professor of physiology at Oxford, in his annual report states that the following research work has been in progress during the present year : (1) The Professor and Mr. G. J. Burch. Upon the Electromotive properties of *Malapterurus electricus*, being a continuation of previous work on the subject. (2) The Professor. On the Tendon Effect and on the Influence of Temperature upon Excitability and Conductivity. (3) The Regius Professor of Medicine. On Muscular Contraction. (4) Dr. J. S. Haldane and Professor Lorrain Smith. On the Oxygen Tension of Arterial Blood, the Detection of Carbonic Oxide in Air and Blood, the Action of Nitrites upon Blood, etc. (5) Dr. Mann. On the Changes in Nerve Cells Associated with their Activity. (6) Mr. W. H. Vernon. On the Respiratory changes of Cold-blooded Animals. (7) Miss Huie. On the Changes in the Cells of *Drosera*. (8) Professor Sherrington and Mr. J. S. Macdonald. On the Neuro-muscular Mechanism of Respiration. (9) Mr. Buddicom. On the Effect of Ether and other Gases upon Nerve Excitability, etc. (10) Mr. W. E. Stainer. On the peptic properties of Pitcher-plant liquid.

UNIVERSITY AND EDUCATIONAL NEWS.

THE University of Berlin has set an example in maintaining academic freedom by electing as Rector for the coming year Professor Gustav Schmoller, who is supposed to have incurred the enmity of the Emperor by the character of his lectures on political economy.

THE Paris correspondent of the London *Times* states that under the law of July 10, 1896, decrees have been issued for the government of universities. Each university is to have a council consisting of the rector, the heads of faculties, and two delegates of each faculty elected triennially by the professors. The council, subject in certain cases to the approval of the supreme education council, will have control over the teaching, discipline, and property of the university. It will, however,

have merely a consultative voice on the finances, and on the creation, abolition or transformation of professorships, for the State will continue to pay the stipends. The maintenance of buildings, on the other hand, will fall on the university, and must be defrayed from students' fees or from endowments. The State takes the fees for examinations and State diplomas, but all other fees go to the university treasury. It will, therefore, be to the interest of each university to attract as many students as possible. The receipts of Paris University are estimated at 600,000f. and of Lyons at 130,-000f., but Besançon and Clermont have at present only 700f. or 800f., and will obviously have to solicit subsidies either from the State or from local bodies. Failing this, the smaller universities are likely to succumb. One of the features of the new system is that a student will, as in Germany, be able to migrate from one university to another without lengthening his studies or delaying his degree.

THE Swiss government has for several years offered *courses de vacance* or university extension courses at Lausanne and Geneva, which have been attended by numbers of American, English and other foreign students. The Department of Public Instruction has now decided to supplement the courses given by the Faculty of Letters by adding to the program scientific and historical excursions, with lectures given gratuitously by university professors.

AT the meeting of the London County Council on July 20th the Technical Educational Board presented their report for the preceding quarter. It stated that arrangements had been made with King's College and University College for evening courses of instruction, to be given to persons who are engaged during the day, in civil engineering, mechanical engineering, architecture, natural philosophy, pure mathematics, electrical engineering, magnetic and electric currents, the strength of materials, the principles of practical physiology, experimental physics, and the teaching of mathematics. Arrangements had also been made for a Saturday morning course to teachers to be held at Bedford College. In the teachers' courses the aim would be to explain the best educational methods of teaching the respective

subjects to their pupils and not to prepare the teachers to pass examinations. The payments made by the Board during the quarter amounted to about \$100,000.

DEGREES of a 'Chicago National University' have been for sale in London. The *Times* states that it has "received a telegram from Mr. Francis Harkins, the Chancellor of the Chicago National University, stating that that university repudiates agents who offer degrees on payment of a guinea." There are five hundred colleges and universities in the United States entitled to confer degrees, but the 'Chicago National University' is not one of them.

MISS MARTHA VEEDER has been appointed professor of mathematics at Huguenot College, Cape Colony.

M. JUMELLE has been made assistant professor of botany, and M. Beaulard assistant professor of physics in the faculty of sciences of Grenoble, and M. Brunhes has been made professor of physics in the faculty of sciences of Dijon.

DISCUSSION AND CORRESPONDENCE.

METEOROLOGICAL OBSERVATIONS DURING AN ATLANTIC VOYAGE.

TO THE EDITOR OF SCIENCE: A few notes of meteorological interest, made during a recent voyage from New York to Rio de Janeiro, may not be unwelcome to the readers of SCIENCE. The trip itself is one which cannot fail to interest anyone who has a knowledge of meteorology, for the steamer route crosses several of the great wind and calm belts of the world, and the characteristic features of each belt are brought into striking contrast as the ship passes from prevailing westerlies into 'horse latitudes,' and then successively through N. E. trades, 'doldrums' and S. E. trades, the voyage ending in the 'horse latitude' belt of the southern hemisphere. A teacher of meteorology who has the good fortune to take this voyage must constantly feel how grand an opportunity the trip would give him to teach the great facts of this science to a class of students, if he could only take his class with him. It would indeed be field-work, if such an expression may be used, on a magnificent scale.

The formation of cumulus clouds over islands has been noted by many observers in different parts of the world, but is always of interest. On June 8th, early in the afternoon, the ship was some distance to the eastward of Bermuda. The sky, except in the west, was covered with strato-cumulus clouds, and the wind was light from S. S. W. On the western horizon the sky was lighter, and the sun was shining on the low clouds. In this direction, which was that in which Bermuda lay, could be seen a considerable number of cumulus clouds, radiating from below the western horizon, and moving across the sky to the N. E. These were evidently coming from the island, for in no other part of the sky were there any other cumulus clouds to be seen. The cumuli diminished rapidly in size as they increased their distance from their place of origin, and they were lost sight of as the ship's course took her farther away from the island. Another observation of cumulus clouds formed over land was made on the morning of June 23d, when about 10 miles off shore north of Bahia. There was a splendid development of cumuli over the land, the shore-line to the north and south being outlined in the sky by the clouds, while over the ocean there were only a few scattered trade cumuli.

On June 9th (noon position 29°43' N., 59°23' W.), between 3 and 4 p. m., there was a fine opportunity to study the growth and mechanism of an advancing thunderstorm. These storms, as the writer has pointed out in an account of the thunderstorms of New England, advance, when well developed, in a long line (storm-front), but their activity is not the same all along this line. In some places where there is more active convectional ascent the rain and thunder and lightning are more severe, while at other points along the same storm-front there may be no rainfall, and the clouds may even seem to break away. It is these apparent breaks along the storm-front which give rise to the common statement that thunderstorms 'divide' over an observer, when in reality there is no true division. On the day in question the thunderstorm when first noted was a single large cumulo-nimbus cloud to the west, and the heaviest rain could distinctly be

seen falling below those portions of the cloud which showed the most lofty tops. These extra heavy rains were seen falling in three places under the main mass of the cloud, and over each of these places the height of the cloud was noted as being especially great. While watching this cumulo-nimbus it was noticed that to the south of it there were some cumulus clouds developing rapidly into cumulo-nimbus and becoming part of the same cloud as that first observed. In this way the storm-front was seen to be extending itself gradually farther and farther to the south, new cumulus clouds continually developing into cumulo-nimbus and joining themselves to the parent storm-cloud. Thus, in an hour, more or less, a long storm-front was developed, extending with a N. E.-S.W. front across the greater part of the western sky. The movement was to the N. E. Careful observation of the storm-front showed distinctly the centers of extra heavy rainfall and the lighter portions in between these centers. In these lighter portions either no rain or light rain was falling.

At sunset on June 18th, in the S. E. trade (noon position, $0^{\circ}16'N.$, $38^{\circ}47'W.$), some observations of degrading cumuli were interesting. The afternoon sky was fairly well covered with trade cumuli, some of the clouds almost reaching the cumulo-nimbus stage. Just after sunset careful observation of these clouds showed them dissolving and toppling over in a very striking manner. The clouds were in shadow, and were clearly outlined against the bright sunset sky behind them. The process of disintegration was of two kinds. In the first the top of the cloud, bending forward in the direction of the prevailing wind, simply toppled over to the northwest, breaking off, so to speak, at the point where it joined the main cloud mass. The upper part, after toppling over, quickly evaporated, and a long line of trade cumulus would thus lose their typical form and become flattened out into a long band, which, in time, also broke up and faded away. In the second kind of disintegration the *shape* of the top of the cloud remained unchanged during the process, the cloud particles simply dissolving as they kept their position with relation to the cloud base. Thus, in a few minutes, only the

skeleton of the top of the cloud was left, and this also soon evaporated, leaving, as in the first process, a long flat band of cloud. The two processes were quite distinct, although they were both processes of disintegration. In explanation of these phenomena, it appeared that the second kind of disintegration occurred only when the clouds were large and well developed, *i. e.*, where the supply of water vapor from below was probably still active, and the effect of the faster-moving upper air in blowing forward the top was not so strong in consequence. For this reason, the cloud kept its shape well, dissolving without being toppled over, while in the first case the cloud was probably in a stagnant condition, and its top offered less resistance to being blown over.

In conclusion, a few directions of cloud movement may be of interest, although comment on them is omitted by reason of lack of time at the present writing.

June 10. Lat. $26^{\circ}58'N.$, Long. $55^{\circ}41'W.$ Cirro-stratus from N. W. June 11. Lat. $23^{\circ}45'N.$, Long. $52^{\circ}30'W.$ Cirrus from S. W. June 13. Lat. $16^{\circ}35'N.$, Long. $47^{\circ}34'W.$ Low fracto-cumulus from E. N. E. (wind direction); alto-cumulus from N. E. June 17. Lat. $3^{\circ}29'N.$, Long. $40^{\circ}44'W.$ Cirro-cumulus from E.; cumulus from S. E. (wind direction). June 18. On equator. Cirrus and cirro-cumulus from E. by S. June 19. Lat. $2^{\circ}42'S.$, Long. $36^{\circ}43'W.$ Cirro-stratus from E. by S.

R. DE C. WARD.

BUENOS AYRES, July 14, 1897.

SCIENTIFIC LITERATURE.

Travels in West Africa. By MARY H. KINGSLEY. The Macmillan Co. 1897. 16 plates, 29 illustrations in the text. Pp. xvi. + 743. Cloth \$6.50

An interesting book in spite of some defects. It takes Miss Kingsley 120 pages to get settled down to the subject of her 'beloved southwest coast'; and the 400th page is passed before you reach the valuable portion of the book.

There is little, past, present, or even future, in connection with West Africa that does not get a touch from her facile pen. There is however an easy flippancy of manner in the story

which carries you on, in spite of a knowledge that the writer is 'on very thin ice' a great deal of the time. The off-hand way in which some rather serious problems are treated is hardly fair, even if we should agree with the sarcasm of some of her criticisms of isolated cases. For example, much space is devoted to the discussion of the subject of the need of proper training for the natives. And where the mission schools go to work along the lines of tailoring, printing, bookbinding, etc., many of which West Africa is certainly not in the most urgent need of, we should agree that they could employ their time much better upon such subjects as smithwork, carpentering or, best of all, agriculture. Our young lady, however, is never tired of quoting Dr. Nassau, for his great learning on the subject of the blacks, and then pokes fun at his efforts and those of some of his colleagues, forgetting that the seamy side of the garment of civilization as applied to the West Coast is probably just as apparent to them as to her, during her rather picnic-like excursions into these regions.

As an example, "even sewing, washing and ironing are a little ahead of time. When the girl goes back to her husband with her two dresses she will soon be reduced to a single dirty rag, which will answer for dress, sheet, towel and dish cloth, and then think of the envy and jealousy of the other wives, and the state of feeling induced by such style. Washing and ironing become parlor accomplishments when your husband does not wear a shirt, and when household linen is non-existent." One might ask the question, What is the use of trying to do anything?

Some of the writer's conclusions form very interesting reading. One of the new reasons given for polygamy is that the man of the house is liable to 'get enough to eat.' But when, after getting fast on a sand bank, and trying to haul off by fastening a line to the trees on the main bank, and succeeding in pulling away the bank, trees and all, she reaches the conclusion that 'Africa is a rotten Continent,' we cannot help but admire the stoical cheerfulness which is certainly the prime requisite for a good traveller.

One of her 'hints to travellers' is worthy

of a wide circulation, namely, to always learn the word or words meaning 'I don't know!' as instances are given where four villages and two rivers have been graced with words bearing this interpretation, which does not tend to geographical clearness. Another feature might be added, drawn from the fact that rivers are sometimes called by one name going up, and by another going down the current.

The really valuable portion of the book is that devoted to the subject of fetishism. Here the inspiration of Dr. Nassau is plainly visible, though there is a great deal of clear insight and common sense used in the interpretation of some of these difficult problems. It is a valuable contribution to our knowledge of the subject.

There are five appendices to the work. The first two are by the authoress upon Trade and Labor on the West Coast and upon Labor. These are followed by a chapter by Dr. Günther describing her collection of fish and reptiles. Appendix IV. is by Mr. Kirby, of the British Museum, on the insects obtained from the Ogowe region. The last is a legend of the origin of the cloth loom.

WILLIAM LIBBEY.

PRINCETON UNIVERSITY.

The Microscope and Microscopical Methods. By SIMON HENRY GAGE. Sixth edition. Rewritten, greatly enlarged. Comstock Publishing Company, Ithaca, New York. 1896. Octavo; pp. xii+237; 165 figures, 1 plate.

The appearance of a new edition of Professor Gage's work on 'The Microscope' calls for notice, since the addition of a large number of figures and about 90 pages of new material have made it practically a new book. As stated in the preface, the plan of the work is: 'Actual experiments carried on by the student himself; and in this respect the book is probably unique in its field, and, it is needless to say, thoroughly in accord with the modern scientific method. In the preparation of the book Professor Gage has drawn upon his long experience and numerous publications on microscopic technique, and in particular subjects has taken pains to consult specialists whose authority would not be questioned and to whom due acknowledg-

ment is made in various places. The extensive scope of the book is well shown by an outline of the various chapters: (1) The microscope and its parts. (2) The manipulation of the same. (3) The interpretation of images. (4) Magnification and measurement. (5) Drawing. (6) Micro-spectroscope and polariscope. (7) Technique of the object. (8) Photo-micrography.

To these are added a copious appendix on methods of testing and on preparing figures for publication, while the whole is terminated by an extensive bibliographical list and by a good index. The bibliography is to be especially commended for its accuracy and completeness. A careful review of its five pages of closely printed type discloses only one omission, though that is rather a striking one, the *Zeitschrift für angewandte Mikroskopie*.

The book is full of valuable information, not only for the student, but for those of considerable experience in microscopic technique, and the number of good hints which are given is very large. Of course, every man has his own ideas with reference to details of technique, and undoubtedly no one would agree with the exact plan outlined by the author. For instance, some would undoubtedly criticise the statements that balsam mounts should be sealed, as also that collodion is the most generally available imbedding material. Many will find fault with the detail of instruction given for the use of the mathematical tables. These are, however, particulars in which the manual is suited to the course given by Professor Gage, and easily capable of omission by those who use the book with other ideas in mind.

It may be fairly questioned whether the amount of space given to the microscope and its accessories from an optical standpoint is not excessive; as compared with Behrens, Kossel & Schiefferdecker, for instance, the extent of space devoted to this branch of the topic is rather striking. In the latter work about 30 per cent. of the space is devoted to the instrument, while 50 per cent. is spent in the consideration of the preparation of the object. In Professor Gage's book the microscope and its accessories occupy about 80 per cent. of the entire work; and even when one considers that some parts are discussed here more fully in the

light of recent development in certain branches of the subject, it is still questionable whether the technique of the object has not been slighted in favor of the technique of the instrument. As the reviewer has pointed out elsewhere, it is undoubtedly by the development in the manipulation of the object that recent years have advanced so far, and it is to this advance that we are indebted for our rapidly growing knowledge with reference to more fundamental phenomena of biological science. Some years ago in his address, 'A Plea for Physiological Histology,' Professor Gage himself emphasized this side of the question. The various methods of reconstruction are, in the opinion of the reviewer, of much greater general importance to the student in every branch of biological science than some of the difficult mathematical discussions of optics which are treated at length in the book, and yet the topic of reconstruction has not even been mentioned. This is all the more striking when one recalls that we are indebted to Mrs. Gage for a most admirable and inexpensive method of reconstruction, and when the various methods have been so largely applied both by her and by the author in their various researches.

The treatment of the microscope as an optical instrument, with its various accessories, is exceedingly complete; so much so that Professor Gage gives us fourteen full pages of cuts of microscopes, in which good, bad and indifferent stands are mixed with rare impartiality. There is no discussion of the principles on which the construction of the various types is based, and no choice expressed with reference to which are the most reliable or would best perform certain sorts of work. The beginner, or even a student of some experience, would sit dazed before this collection of figures in his efforts to decide which he needed. The inclusion of so many cuts was, perhaps, a necessity of the case, seeing that the electrotypes were donated by the manufacturers and it would have been unwise to have slighted any particular firm; and yet it might have helped a little to have discussed briefly the general principles of construction involved.

Among minor defects one might mention a lack of care in type-reading, which shows itself

in the use of both m.m. and mm. several times on the same page, and in the recurrence of various misspelled names. It is certainly amusing to learn that an article can easily be made by a *tin smith*. One notices, also, an occasional slip of the pen, as a result of which figure and text do not always agree. Thus, the mechanical stage, shown in figure 69, does not possess verniers, despite the statement in the description of the cut, and the absence of this feature is undoubtedly a serious defect in the construction of the stage as compared with that of another maker which is shown in the adjacent figure. The excessive number and length of the foot-notes in the book mar the beauty of the page, and many of them might easily have been incorporated in the text. It is further true that the constant use of vulgar fractions, which have no place in a scientific text-book, is another point to be justly criticised. Their employment also is not limited to such as are difficult to translate into decimal figures, but $\frac{1}{10}$, $\frac{5}{10}$ mm., etc., are of constant occurrence.

While it would be manifestly unfair to give an idea of the book based merely on these criticisms of minor details, it is evidently impossible to do more than hint at some of the many advantageous features which it contains. The synopses of the steps in the preparation of paraffin and collodion sections are of exceeding value to any student and will doubtless save much time and many errors. Throughout the book one finds very complete cross references and satisfactory bibliographical notes which will be of constant use to the worker. Every topic is completely and concisely discussed; the order is clear and logical, and one is at a loss to suggest points that have been overlooked.

The chapter on Photo-micrography deserves especial mention. It includes much that cannot be found elsewhere and is altogether the best concise statement of the subject which is accessible. This chapter is worth more than the price of the entire work. Like the rest of the book, it is copiously illustrated; the figures are exceptionally well chosen, and among them are a couple of splendid photo-micrographs from the work of Mrs. Gage, who also drew all the original figures by which the work is illustrated.

As a whole, the work is a useful and valuable addition to the manuals accessible to the American teacher and is destined to be widely and generally used.

HENRY BALDWIN WARD.

The Chances of Death and other Studies in Evolution. KARL PEARSON. Edward Arnold, London and New York. Vol. I., pp. ix+388; vol. II., pp. 460. \$8.00.

Professor Pearson's essays and lectures fall into three groups. One of these is concerned with the theory of deviations from the mean in its application to vital and social phenomena, another with a criticism of certain popular writers who have exploited science for the benefit of religion and politics, and the third with studies in folk-lore and folk-customs, viewed from the light they cast on the evolution of society. All of the essays are of great contemporary interest, and have to a considerable degree the unity claimed by the author, 'the endeavor to see all phenomena, physical and social, as a connected growth, and describe them as such in the briefest formula possible.'

The essays on variation in this volume, and the series of papers on the mathematical theory of evolution published in the *Transactions and Proceedings* of the Royal Society since 1894, represent a scientific advance of great importance. Modern science pursues two main methods; it is either quantitative or genetic. The exact sciences have found in measurement a method of description so efficient, economical and universal that it must be regarded as the goal of those sciences in which description is only qualitative. The genetic method has, however, since the publication of the 'Origin of Species by Means of Natural Selection,' demonstrated its validity. Could we add to the genetic method of natural science the quantitative method of exact science a great advance would be assured.

It is not possible to describe in a few words what has in fact been accomplished since Quetelet applied the Gauss theory of the distribution of errors to vital phenomena. If any trait, such as the height of men, depends on a great number of small causes, some tending to make them smaller and an equal number tending to

make them larger, then theoretically the deviations from the mean will be distributed in a certain symmetrical fashion, and measurements show that such a distribution does in fact approximately obtain. According to the Darwinian theory such chance variations as proved useful have by natural selection been preserved, and have given rise to new species and to organic evolution. The quantitative study of these variations, especially in their relations to heredity, is, I believe, the most pressing problem of biological science. The small amount of work hitherto accomplished has been chiefly carried out in England by Mr. Galton, Mr. Weldon, Mr. Bateson and Mr. Pearson. Mr. Galton has assumed the validity of the theoretical distribution. Mr. Pearson has shown that the distribution may be complex and non-symmetrical, and has subjected it to mathematical analyses.

Turning now to the essays in this book, which are of special value because the scientific papers of the author are of such a technical character, as to make them unintelligible to many naturalists, we find the first to be on 'The Chances of Death.' Mr. Pearson explains the theory of deviations from the mean, and shows how mortality statistics may be analyzed into five 'skew' curves. Thus 'old age' mortality includes about one-half of all deaths. The maximum of the curve is at about 71 years, but it has a 'skewness' toward youth of 0.345. The mean is at about 65 years, with a 'standard deviation' of about 13.5 years and a limit on the old age side of 106.5 years. Components are then found representing the mortality of middle age, of youth, of childhood and of infancy. In the last case Mr. Pearson found that to secure a frequency curve it was necessary to take account of antenatal mortality, and that the curve discovered corresponds fairly well with the facts.

It is quite evident that the regular frequency curve does not represent mortality statistics or, indeed, most social and vital statistics. I have in several publications claimed that the ordinary frequency curve can in all actual cases be but an approximation. Mr. Pearson's skew curves allow us to express the facts with greater approximation, just as the orbits of planets are

more nearly ellipses than circles. But, in fact, the orbits of the planets are endlessly complex, and so are the distributions of errors or deviations. Mr. Pearson claims to give a simple curve for infancy, but the material is not homogeneous. Antenatal mortality is due to causes different from those of infant mortality. The mortality of infants of the two sexes, of different races, of different classes, of those born at different seasons of the year, of those legitimate and those illegitimate, of those nursed by the mother and those brought up by hand, etc., has each a different distribution. In antenatal mortality there is a maximum at each four weeks, a greater maximum in the second and third months, etc. The curve for infancy would, in my opinion, need to be further broken up, quite beyond the possibility of mathematical analysis, in order to express the facts.

The second essay analyzes certain alleged results of Monte Carlo Roulette, and shows that they are deficient in short runs to an almost impossible degree. Presumably the published figures do not represent the actual falls of the ball, or it would be easy to 'break the bank.' The author does not give this explanation, and apparently does not notice that in one case the zeros (where the money goes to the bank) are only 499 instead of a most probable 840, a return perhaps intended to encourage the gambler. I must admit that I do not think that Mr. Pearson has made the best possible use of his time in tossing shillings 25,000 times, etc., in order to test the laws of probability. He might as well measure the sides of 25,000 right-angled triangles in order to see whether the square of the hypotenuse is really equal to the sum of the squares of the other two sides.

The third essay, entitled 'Reproductive Selection,' is concerned with a statistical study of the size of families. The material is of much theoretical interest and of the greatest practical importance. If there is a complete correlation between fertility of parent and offspring, we might expect those having large families to supplant quickly all others, whereas it is not commonly supposed that those most fertile are those most fit for society. From 4,390 families, mostly of middle and upper Anglo-Saxon stock, Mr. Pearson finds that the most frequent

family, the 'mode,' is between two and three; the median family is about $3\frac{1}{2}$ and the mean family one larger. The median fertility is, however, about $5\frac{1}{2}$, and it follows from this that the most fertile quarter of the parents produce one half of the next generation. The same general relations hold for the extensive statistics of Copenhagen families collected by Rubin and Westergaard, but the fertility is greater. In both cases there is a deficiency, according to the theoretical distribution, of families of five and six children, due probably, as Mr. Pearson holds, to voluntary control. I cannot, however, agree with him that the curve shows that control is not exercised in the case of families of other sizes, or that in the case of no children it is excessive. In the latter case there are special anatomical and physiological causes producing sterility, which would not be factors in the amount of fertility.

Mr. Pearson finds that there is a selective death-rate increasing with increased fertility, but it would only slightly check 'reproductive selection,' and he concludes that in the case of civilized man natural selection at present appears to be quite secondary to reproductive selection as a factor of progressive evolution. An extreme Neo-Darwinian might, indeed, find it difficult to tell us why families do not increase indefinitely in size, or why infant mortality does not eliminate itself. We must believe that deviations from the mean are not always stable hereditarily and are in definite directions. The degree to which individual fertility is a stable variation can only be determined by statistics not yet collected. It is, however, clear that race or class fertility, whether due to physiological or psychological causes, will in a comparatively short time produce great changes in every race and in the survival of races. Thus the Bretons are supplanting other French stocks, and our New England stock is in danger of extermination.

The essay on 'Variation in Man and Woman' occupies one-third of the first volume. As the result of some 155 cases of variation for both sexes, covering a wide field, Mr. Pearson finds that woman is, relatively to size, not less, but probably slightly more, variable than man. This is contrary to the common opinion, but

had been proved previously by Mr. Galton for sensation-areas. The variation in brain-weight is of special interest, but the data are so conflicting that they are not of great value; the coefficient of variation is, however, sensibly the same for the two sexes. Mr. Pearson criticises somewhat bitterly those who have assumed, on insufficient evidence, the greater variability of the male and drawn therefrom sociological conclusions. I think, however, that the experience of those who have taught both men and women will favor the greater intellectual variability of the male. The collation of examination papers marked without reference to these matters would be of interest. Supposing the male to be more variable in intellect and character, as seems sufficiently evident from the history of civilization, it would still remain undecided whether this were due to 'nature' or 'nurture,' and sociological inferences can only be drawn with caution.

This volume contains three essays criticising, respectively, Mr. Kidd's 'Social Evolution,' Lord Salisbury's 'President's Address' before the British Association and Mr. Balfour's 'Foundations of Belief.' Mr. Pearson has rather an easy task. Mr. Kidd's book received abundant attention and was lauded by Mr. Wallace in *Nature*, but it is already half forgotten. Mr. Pearson's arguments for the comparative unimportance of intra-group selection for human progress are, however, deserving of consideration. Most men of science will agree with Mr. Pearson's arraignment of Lord Salisbury and Mr. Balfour. It is a particularly futile form of argument to pass from *ignoramus* to *ignorabimus* and thence to *credendum est*. Mr. Pearson holds that the comparative orthodoxy of the Conservative leaders was of much advantage to them in the last elections. The writing of books on science and philosophy is, however, a kind of demagogic of which we should be glad to see some trace in America. Mr. Pearson is undoubtedly correct in stating that thoughtful men of science do not hold the materialistic views attributed to them by Mr. Balfour, but I am not sure that his own idealism helps greatly in treating the problems of physical science. When it is said that in science we are concerned not with phenomena,

but with 'a rational analysis of the contents of the human mind,' this is a statement that does not essentially affect the methods of science; but it seems somewhat dangerous to attempt to lessen the difficulties in the way of correlating atoms and the ether with other physical phenomena by regarding them as 'conceptual limits.'

The only essay in the first volume not yet noticed is concerned with the place of women in society, and with the relations of individualism and socialism—subjects which are more or less distinctly brought forward in many places. The second volume is, indeed, chiefly concerned with them, though indirectly, from the point of view of folk-customs and folk-lore. The four essays included in it are entitled 'Woman as Witch,' 'Ashiepattle,' 'Kindred Group-Marriage' and 'The German Passion-Play.' Limits of space do not permit me to give an account of these, and limitations of knowledge make me incompetent to criticise them. Mr. Pearson attributes great importance to a mother-age and its customs, and emphasizes the fact that mediæval Western Christianity was a product of the Teutonic folk-spirit.

Mr. Pearson's essays and lectures are *actuel* to an unusual degree. The scientific and social problems treated by him are those most pressing for solution and those most likely to become predominant in the course of the next twenty years. It is not too much to say that these volumes should be read by every man of science.

J. McKEEN CATTELL.

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SCIENTIFIC JOURNALS.

AMERICAN CHEMICAL JOURNAL, AUGUST.

On the Oximes of Mucophenoxychloric and Mucophenoxybromic Acids: By H. B. HILL and J. A. WIDTSE. *On the Action of Aluminic Chloride and Benzol upon Mucochloryl Chloride, Mucobromyl Bromide, and the Corresponding Acids:* By H. B. HILL and F. L. DUNLAP. These papers contain the results of investigations which have been carried out under Professor Hill's directions. It had been shown that mucochloric and mucobromic acids, when treated with hydroxylamine, formed normal

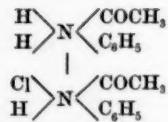
oximes, which would indicate the presence of an aldehyde group in the acids. On the other hand, the bromoanhydrides could be converted into crotonolactones by reduction, indicating an anhydride structure. The tautomerism of these acids has been the basis of the present work. Hill and Cornelison had attempted to discriminate between the two forms by a study of the action of hydroxylamine on the methylester of the acid, expecting to find that one of the forms would react readily, the other with difficulty. Although the free acids acted very quickly, the action with the methylester was very slight. When, however, one hydrogen of the acid was replaced by the phenoxy group, a substance was obtained whose ester acted readily and formed a substance identical with the ester made from the oximes by the action of methyl iodide on the silver salt. The oximes and their derivatives were prepared and studied during the course of this investigation. The simplest explanation that could be offered to explain the conversion of the acids through their bromoanhydrides into crotonolactones was that the acids were oxylactones. This was tested as follows: If the acid has an aldehyde structure it should, on treatment with aluminic chloride and benzol, yield an aldehyde phenylketone, while a substance belonging to the class of oxylactones should form a dichlorophenylcrotonic acid. The latter product was, in fact, the one obtained, and the authors consider the evidence sufficient to warrant the conclusion that the acid and its chloroanhydride have the lactone structure.

On Certain Derivatives of Brommaleic and Chlormaleic Acid-Aldehydes: By H. B. HILL and E. T. ALLEN. The authors repeated the experiments of Limpricht which led to the formation of an acid-aldehyde of fumaric acid; but were unable to isolate any crystalline compound. The viscous liquid which they obtained had, however, the properties of an aldehyde. In attempts to prepare some derivative of this they obtained a product which they showed to be brommaleic acid aldoxime. As this substance had not been previously prepared, its properties and many of its derivatives were studied. All attempts to prepare the acid itself failed. The corresponding chlorine compound can be made by the action of chlorine upon pyromucic acid.

Several interesting transformations were also studied.

On the Absorption of Oxygen by Tetrabromfuran: By H. A. TORREY. Although *a*-dibromfuran is readily oxidized by exposure to the air, tetrabromfuran, which likewise contains two bromine atoms in the *a*-position, undergoes no change under like conditions. Exposure to direct sunlight, however, produces a change which the author has shown to be due to oxidation. The product formed was shown to be dibrommaleyl bromide and the conditions most favorable for the action were studied.

On Halogen Addition-Products of the Anilides: By H. L. WHEELER, B. BARNEs and J. H. PRATT. The authors have continued their work on the perhalides and compared them, as regards their crystallographic form, with the alkali perhalides. They found, however, that the perhalides of the anilides were not analogous in crystal form, and other facts also showed that the compounds from which the perhalides were prepared were not, as was supposed, substituted ammonium compounds. All these are derived from two molecules of an anilide with one of a halogen acid. Several structural formulas are suggested as theoretically possible; but they consider the evidence to favor the di-ammonium structure of which the following is an example:



A number of perhalides were prepared and their properties studied, both from a chemical and physical standpoint.

On the Permeation of Hot Platinum by Gases: By WYATT W. RANDALL. After giving a historical résumé of the work that has a bearing on this point the author gives the results observed in the preparation of pure hydrogen. The form of apparatus used, in which every possible precaution was taken to insure the purity of the hydrogen before it came in contact with the hot platinum, is given in detail. In these experiments the passage of the hydrogen was very slow as compared with the results obtained by Graham. Under the same condi-

tions oxygen and nitrogen do not permeate the tube, and experiments made with marsh gas, which has a density only half that of oxygen, have so far given negative results. The hydrogen was examined spectroscopically, as this method was the most delicate for detecting the presence of other gases. The photographs all showed the so-called 'compound' spectrum. Whether this is evidence of some contamination can not yet be decided, as the evidence is not sufficient to settle this point.

On Some Malonic Acid Derivatives: By R. S. CURTISS. When ethylchloromalonate is treated with cold alcoholic ammonia a compound is formed in which the chlorine atom remains intact; whereas if the action is carried on in a sealed tube at 140° the chlorine atom is displaced. On treating ethylbrommalonate with aniline, a weaker base than ammonia, he obtained, as he expected, a compound in which the bromine was substituted, without affecting the carbethoxyl group. By treating ethylanilidomalonate with mercuric oxide he obtained ethyldianilidomalonate and also studied the action of sodium ethylate on ethyldibrommalonate.

The Action of Nitric Acid on Triphenylmethane: By E. S. SMITH. In attempting to prepare trinitrotriphenylmethane by the action of fuming nitric acid on triphenylmethane the author obtained in one case a compound which was shown to be triphenylcarbinol. This substance is usually made by the use of chromic acid as the oxidizing agent, but in the case mentioned the nitric acid acted in a similar manner.

Reviews of the following recent publications are also contained in this number of the *Journal*: Das Studium der technischen Chemie an den Universitäten und technischen Hochschulen Deutschlands und das Chemiker-Examen, F. Fischer; Water and Public Health, J. H. Fuertes; Fröhling und Schulz's Anleitung zur Untersuchung der für die Zucker-Industrie in Betracht kommenden Rohmaterien, Produkte, Nebenprodukte und Hülffsubstanzen, R. Fröhling; Tabellarische Uebersicht der Pyrazolderivate, G. Cohn; The Chlorination Process, E. B. Wilson; Tabellen für Gasanalysen, gasvolumetrische Analysen, Stickstoffbestimmungen, etc., G. Lunge.

J. ELLIOTT GILPIN.

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